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CONTENTS

Page

Lighting in the Design of Schools, by Anthony Pott, A.R.I.B.A., A.A.Dipl. - 293

Additions to the List of Members - 312

The Design of Interior Lighting Equipment, by L. H. Hubble *(Fellow)* - 313

VOLUME XVII
No. 10 — 1952

32 VICTORIA ST
LONDON, SW1

Annual Subscription to Non-Members - £2.2.0
Price per Number to Non-Members - 5s. 0d.

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Lighting in the Design of Schools

By ANTHONY POTT, A.R.I.B.A., A.A. Dipl.

Summary

Changes in ideas on education, in teaching methods, in building techniques and in economic conditions are combining to produce new forms of school used in new ways. The importance of scale and character is becoming more widely appreciated and the newer teaching methods are demanding rooms which can be used for many different purposes.

The provision of natural and artificial lighting, adequate both in quantity and quality, for these new schools is discussed, and some recent installations and fittings are critically reviewed.

(1) Introduction

The design of any building but the simplest is so complicated a business to-day that it is inevitably a matter for collaboration between a number of designers, each contributing his particular skill to the whole, if a satisfactory building is to result. As R. M. Wynne-Edwards said some years ago: "No single group of men can cover all the ground, as the old master builder did; so the architect, the engineer, the builder and the manufacturer must work together, not in watertight compartments, for unless each has a real understanding of what the other is doing his contribution to the whole will inevitably be limited." An invitation from the Illuminating Engineering Society to an architect to present a paper dealing with a subject connected with lighting is a welcome gesture, as an attempt to counteract the very real danger of watertight compartments. It will be appreciated that this contribution by a general practitioner to an audience of specialists must be at least as much concerned with the problem and with the requirements as with solutions and means. As R. O. Ackerley said in concluding a lecture to the Architectural Science Board on "Artificial Lighting Practice": "In general it is suggested that with architects and lighting engineers as they are to-day, it is for the architect to say what results (not what lighting) he wants and for the lighting expert to advise how he can get that result." His paper had made it clear earlier that to do his part the architect must know more about vision and lighting than most of them would claim to do.

The term "school" as commonly used covers a wide range of buildings, from nursery schools to Colleges of Further Education. The most cursory knowledge of what goes on in these buildings shows that their lighting problems are entirely different and cannot usefully be considered together. To keep this paper within bounds it will be restricted to those types which form the bulk of the present school building programme—namely, primary and secondary schools, and especially the secondary modern school. The latter type not only forms the largest part of the programme of secondary school building but is a new kind of school, a product of the 1944 Education Act, which raises problems of its own educationally and, therefore, architecturally. Organisation, curriculum and teaching method are live subjects of experiment and controversy; the new buildings must at worst allow such experiments to be carried out, and at best encourage and even stimulate them.

The use to which a building is to be put is one important factor in shaping the building. The method by which it is built is a second factor, and the economic conditions under which it is built is a third. All three have combined since the war to

The author is with the Architects and Building Branch of the Ministry of Education. The manuscript of this paper was first received on January 28, 1952, and in revised form on February 29, 1952. Paper presented at the I.E.S. Summer Meeting at Eastbourne, May 23, 1952.

alter ideas about school design. On the developments in ideas on education and in teaching methods, the architect is not qualified to speak, so the paper must be restricted to mentioning some of the ways in which these developments influence the shaping of the school. On the techniques of building, it is enough to say that scarcity of materials and labour is leading to the widespread study of building methods which save both or either of these; one approach to these problems was described by Johnson-Marshall in a paper(1) to the Building Research Congress. Finally, the cost of schools is strictly limited.

There are two current ideas about school building in these conditions which are so common that it is worth referring to them. One is that schools are in danger of becoming "standardised"; in fact, the opposite is nearer to the truth. The re-examination of principles both of planning and building means that a greater variety of solutions is being tried, and there is less opportunity for the adoption of well-tried formulae. As Lawrence B. Perkins, an American architect, said in his paper on schools at the Building Research Congress: "Fortunately, material shortages often make it difficult to follow the easy, traditional way. They foster the exercise of creative ingenuity."

The second misconception is that limitations on the cost of schools must necessarily mean worse schools. Carried to excess, they will; but before that point is reached such limitations provide another stimulus to hard thought and "the exercise of creative ingenuity," and so to better schools.

(2) Trends in Planning

An example of the way in which these influences combine to affect schools can be seen in the heights of rooms in some of the newer schools. It is important if the right character is to be achieved that the school, in part and in whole, shall be in scale with the children using it. This is especially important in infants' schools, to which children come with experience only of their homes. The reduction of ceiling heights helps to get this scale, and the consequent reduction of the cubic content of the building helps to lower the cost—at the expense, however, of considerably complicating some of the other problems.

Arising from newer teaching methods is a trend that can be seen in some schools towards abandoning the straightforward rectangle plan for class spaces. A central space with alcoves or bays not only helps to get the scale which is needed, but may be a positive advantage when the freer teaching methods are in use and the class is broken down into a number of small groups each pursuing its own interests of the moment. This kind of shape can also result from other planning considerations; for instance, it may result from throwing some of the storage area, previously a separate store-room, into the classroom itself, forming an alcove containing a cupboard in which can be stored those things which must be locked up; or it may result from forming a bay to house a sink or work bench.

While these trends in planning are most marked so far in primary schools, they are also noticeable in secondary modern schools. In these schools much of the work is likely to have a practical bent, and "project" work will probably increase considerably; this in turn means that the room must be adaptable to many different kinds of activity besides formal teaching from the blackboard. "Chalk and talk," as the conventional method has been described, will survive to some extent, no doubt, but the tendency in contemporary teaching methods is to destroy the hard-and-fast distinction between formal (or academic) and practical work in schools, and hence of the kind of work which will be undertaken in any one room.

This tendency to plan the general teaching space ("classroom") as a multipurpose room is indicative of another general trend which can be discerned in school planning to-day—that towards reducing the amount of highly specialised accommodation

and increasing the number of spaces that can be used for several different purposes. (Incidentally, no room is so highly specialised as the 480-sq.-ft. classroom, which can only accommodate a class of 30 children if the desks or tables are arranged in rows, and—a more difficult task—kept there.) This tendency is reinforced by the need for economy, because single-purpose teaching-rooms have often led in the past to the provision of a great deal of building, large parts of which have been unused for a considerable proportion of the school day.

There is a growing tendency to build schools on more than one floor. This is a reversal of the practice immediately after the war, when the majority of schools were single-storey buildings. Several influences are combining to bring this about; the need for economy in the use of sites, in the total area of building and, within this total, in the area used solely for circulation, combines with the belief that more compact schools have positive educational advantages. The latest examples of this movement towards compactness include some multi-storey schools planned with double-banked rooms on each side of the corridor, a development to which reference is made later.

An example of the kind of extravagance in space which has been mentioned is often seen in the use of the Assembly Hall. A large hall, designed as an impressive focus for the corporate life of the school, is sometimes used fully only for a short assembly in the morning and for a few " grand " occasions during the year. For the rest of the time it either stands empty or is used for informal drama, music or dancing by small groups of children for which its size can be a positive disadvantage. The present limitations on the amount of special accommodation which can be allowed, say, for physical education or for dining, is leading to a re-examination of the use and design of assembly halls and is producing interesting new solutions, allowing the halls to be used more fully and thus to earn their keep.

These examples of some of the changes which are affecting school design will also affect in many ways the lighting of schools, and increase the need for close collaboration between everyone concerned if satisfactory solutions to the problems are to be found, and found at the right cost.

(3) Lighting Standards

There is no need to argue the importance of good lighting in schools. If there is less readiness to-day to believe, on the available evidence, that there is a direct relationship between defective sight in school children and school lighting, experience in the post-war schools shows that many teachers are of the opinion that both they and the children benefit in many ways from good lighting, even though some of these benefits cannot be defined in precise terms.

A non-technical definition of a good lighting scheme for a school is that it is one that provides enough light on the children's work to enable the normal child to perform the visual tasks undertaken in school comfortably and without strain; this implies an absence of glare and a careful relationship of the brightness of all the surfaces of the room to that of the work or, more exactly, " the central visual field."

The present School Premises Regulations[2] require that all rooms shall be " appropriately " lit with a minimum level of maintained illumination on the appropriate plane of 10 lm./ft.^{2} and 2 per cent. Daylight Factor in all teaching accommodation and kitchens. " Teaching accommodation " is defined as all the internal space in a school required for teaching by any method. This standard of 10 lm./ft.^{2} is lower than is recommended in the Illuminating Engineering Society's Code and very much lower than the minima in the " American Standard Practice for School Lighting "[3] (30 lm./ft.^{2} for classrooms, etc.), but remembering that it is a minimum and not a recommended level it does not appear unduly low in the light of the work by Hopkinson and his colleagues at the Building Research Station[4, 6, 7, 8]. These and other studies by the Building Research Station have formed the basis of the

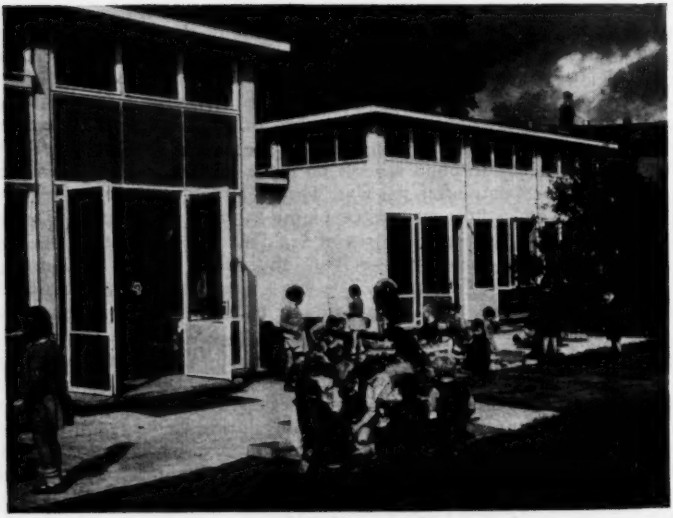

Fig. 1. Showing arrangement of windows at different levels.

Regulations, which have the approval of the Joint Committee of the Medical Research Council and the Building Research Board. This committee considered the proposals in technical form at an early stage, and later when they had been recast in a form suitable for issue as Regulations. We can hope that higher levels of illumination, of special advantage to children of sub-normal sight, will be adopted when the importance of the design of the whole "visual environment" is more widely appreciated and we have gained further experience of school lighting. It can be taken as a good omen that the new Regulations break fresh ground in their concern, in however elementary a form, with quality as well as with quantity of light.

(4) Natural Lighting

Schools are mainly naturally-lit. If the hours during which schools are used for their principal purpose are considered, it is clear that the main job of the artificial lighting installation is to supplement the natural lighting when the daylight is inadequate. A computation by the Building Research Station, based on data of the National Physical Laboratory on daylight illumination measurements at Teddington, shows that the total time during school hours in a year during which this supplementary artificial lighting is necessary may be as little as 50-60 hours. A minimum sky factor of 2 per cent., giving a minimum daylight factor of 5 per cent., is assumed. This ratio of sky factor to daylight factor is an estimate based on measurements in a number of schools designed to a 2 per cent. sky factor. Of course, these figures for the hours of artificial lighting do not take into account the use of schools during the evenings and outside school hours by clubs, evening institutes, and so on.

Daylighting requirements have caused the teaching rooms in most post-war schools to be lit by windows in at least two walls. This is the most obvious solution to the problems of adequately lighting the back part of deep rooms and of reducing the contrast between the brightness of the window and that of the wall in which it is set. A "window-wall" on one side with clerestory lighting from the opposite wall has been the most common solution in post-war schools and is seen in many plans of the dispersed or "finger-plan" type, with teaching spaces on one side only of a corridor.

This kind of plan is unsatisfactory for several reasons: it is usually uneconomical in space (area per child) and sometimes in the use of the site; its linear form makes it difficult and sometimes costly to fit to a sloping site; in any but the smallest schools it can easily produce an unpleasant architectural effect with long, bleak corridors giving an inappropriate "institutional" character; and finally, unless these long corridors are kept a reasonable height, they become depressingly tunnel-like, and if this is avoided the classrooms are of necessity over-high.

These and other defects of the dispersed plan have led architects to seek other solutions for both single-storey schools and for those on more than one floor. Various arrangements of windows at different levels in two or sometimes three adjacent walls have been tried, some with interesting and successful results (Fig. 1). Some of these are limited to use in certain types of plan, and this serves to emphasise that natural lighting must take its proper place among the other factors in the early stages of planning. How "proper" is interpreted will depend upon the architect who has to decide the relative importance of *all* the factors in the circumstances of the particular job; and it should be added, with certain extreme examples in mind, that it does not mean that a whole school can be designed around some particular cross-section which is believed by its designer to provide the perfect answer to the problem of natural lighting.

A fairly recent development in the natural lighting of teaching rooms is the introduction of top-lighting (Fig. 2). The use of this is obviously limited to single-story buildings and to top floors, but it should not be overlooked that part of many "multi-storey" schools is of one storey only, and in some this part is a large one. There is,

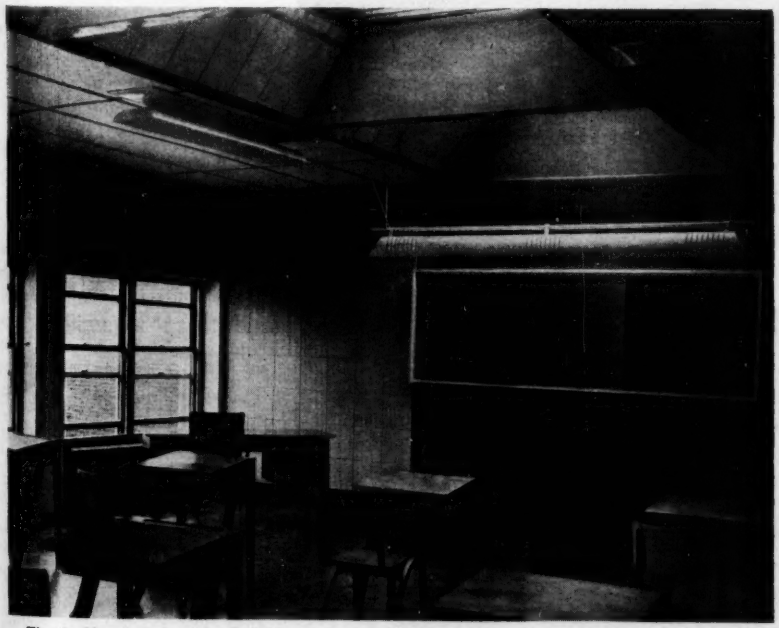

Fig. 2. Showing use of top lighting to improve daytime conditions in single storey buildings and top floors.

therefore, great scope for ingenuity and experiment in the design and use of top-lighting. The defects of top-lights are only too well known: they often let too much sunlight in and too much heat out; the control of light and ventilation through them usually involves complicated mechanism; and they are nearly always more expensive than was hoped. There is no reason, however, why these technical and economic problems cannot be overcome. The use of quite small top-lights (in relatively deep roof constructions) has proved satisfactory in some positions and at a reasonable cost, and this seems a promising line for further development. Simple fixed louvres may be necessary and the achievement of satisfactory relationships of the brightness of the surrounding surfaces needs care.

This last point leads to what may be the most important feature of natural lighting practice at the present, namely, too exclusive a concern with the quantity of light. Generally, in post-war schools, there is enough light on the working plane; a 2 per cent. sky factor combined with the reflection factors of decorations usually found in contemporary schools seem, from experience, to achieve that. But modern lighting practice should view that as a start only, the end being a stimulating and comfortable "visual environment" which enables the occupants to make best use of the light which is provided. The "American Standard Practice for School Lighting" goes as far as to give "Quality of Illumination" precedence over "Quantity of Illumination." One of the reasons for reserving judgment on the proposals to "double-bank" teaching rooms on each side of a central corridor in multi-story schools is doubt about the quality of the natural lighting which will result. Suitably proportioned

Fig. 3. A classroom in which venetian blinds with adjustable louvres are used to control daylighting.

rooms can be lit from one side only and still satisfy the requirements of the Regulations, namely, a minimum daylight factor of 2 per cent. on the working plane, but it is undoubtedly much harder in these conditions to obtain a generally satisfactory visual environment.

As one example of this neglect of considerations of quality, many schools have inadequate or no control of the direct view of the sky, which may have a brightness of 5,000 ft.-lamberts in the most brilliant summer conditions. Even when the sky brightness is as low as 1,000 ft.-lamberts—which it may be on a bright winter day—it is distracting, and above that it rapidly becomes uncomfortable. In addition, the large windows commonly found in schools can produce disability glare with very much lower sky brightnesses. It is obvious, therefore, that if any tolerable relationship is to be established between the brightness of the sky and the other surfaces within view some form of "daylight control" is necessary.

There seems little doubt that the venetian blind with adjustable louvres is the solution to the problems of daylight control (Fig. 3), but their high initial cost tells against their general use. There is also scope for improvement, optically and mechanically, in some blinds of this type; and it is essential that teachers get some instruction in their manipulation if the blinds are to be used to best advantage. But properly used they can exclude direct sunlight, limit the view of the sky and eliminate reflected glare while admitting some light by reflection from the ceiling and allowing natural ventilation. Experience in the schools in which they have been used shows generally that they are satisfactory in practice. At the other extreme, the use of simple net curtains seems to deserve a trial in schools in this country. They will satisfactorily control daylight and sunlight under all conditions except those of direct low-angle sun; their practical disadvantages are obvious, but against these must be set their low first cost.

Many methods of daylight control have been tried in the United States, and it was therefore interesting to read Biesele's statement in his paper[5] to the Building Research Congress: "Our studies have indicated that the interior venetian blind is probably the most satisfactory daylight control device available commercially." Incidentally, it would appear that prismatic glass blocks, which have been a noticeable feature of some American schools illustrated in the technical papers, now seem to be under heavy fire in the United States on grounds of excessive brightness in some conditions, lack of transmission in others, and the complications in natural ventilation which are caused by their use.

Finally, the design of the windows and their relationship to the walls, ceiling and floor can do much to increase visual comfort or at least diminish discomfort. Within the present limits of cost it may not be possible to go as far in the refinement of details as one would like, but an awareness of the importance of reducing contrasts, grading the brightness of surfaces and so on will make the architect prepared to seize any opportunities which arise.

(5) Artificial Lighting

The artificial lighting of schools must have the same end as the natural lighting: it should provide enough light to enable the normal child to perform the visual tasks undertaken in schools comfortably and without strain. Really skilful lighting may do more than this and may help to stimulate teachers and children to do their best work.

The Standards for Schools Premises Regulations, 1951[2], mark an important advance over the previous regulations, because they deal with some qualitative aspects of lighting as well as with the quantitative ones. While good lighting cannot be assured by means of any regulations, they perform a useful function by drawing

attention to some of the factors affecting quality and keeping them in the minds of those concerned with schools.

The essentials in lighting teaching spaces are :—

(i) There must be enough light on the work. How much this is to be is left by the regulations to the designer, whose decision will be influenced by all the conditions of the particular job—subject only to maintaining the minimum illumination level of 10 lm./ft.^{2} over areas of normal use in all teaching accommodation and kitchens.

(ii) If visual efficiency and comfort are to be achieved, the brightness of the light source must be limited. This is referred to in the regulations, and implies not only specified angles of cut-off for the lamp, but the careful design of the fitting to limit its surface brightness to 1,000 ft.-lamberts.

(iii) The brightnesses of all the surfaces in the field must be related to one another so that excessive contrasts of brightness are avoided; here the regulations say soundly, but vaguely, that the fittings shall distribute some of their light "so as to prevent excessive contrast between the fittings and their background."

These regulations, however sketchy they may be, have the merits of putting first things first—and the firsts in the right order of priority. It is doubtful if the more subtle points of design will ever be susceptible of codification and regulation, even in fields such as lighting which are based on the physical sciences.

The provision of adequate light on the working plane presents no technical problem by itself, but the cost may be considerably influenced by the proportions of the room. It should be noted that the whole of "the area of normal use" must receive the minimum illumination and, in the light of what has already been said on the ways in which rooms are used, great caution must be exercised in assuming any particular arrangement of furniture and equipment. Only in very specialised rooms are such arrangements likely to be unalterable and even in these the flexibility provided by good general lighting is valuable.

In rooms with a fixed chalkboard some supplementary lighting will probably be necessary if the board and its surroundings are to be illuminated to a level of 10 lm./ft.^{2} This figure should be regarded as a minimum and should be increased if possible, especially in secondary schools of the type in which there is formal teaching of subjects involving complicated detail on the blackboard, e.g., algebra. For chalkboard lighting, fittings which can be directed on to walls other than the chalkboard wall are valuable; "pin-up" boards are increasingly used in all types of schools and there is no certainty that the chalkboard area will be used for charts, maps and diagrams. Such fittings will also be valuable if a mobile chalkboard is used. Recent work[4, 6] at the Building Research Station has shown that the optimum reflection factor of a grey chalkboard is about 15 per cent. but that it can be as high as 25 per cent. without serious loss in visual efficiency. Care must be taken, however, that chalkboards with high reflection factors are not also highly coloured[6]; the saturation should not exceed Munsell Chroma 5.

To go back to the surface brightness of fittings: it is easy if one has the knowledge to lay down a limiting figure, but it is very difficult, and probably impossible at present, to state by how much, and over what area, this figure can be exceeded. Yet it seems to many architects, at least, that uniformly bright fittings are often the first step towards dull lighting, and that by a careful grading of brightness a much more stimulating and attractive result can be attained even though the brightest area exceeds the limits which are usually accepted. It has been suggested that a working rule might be to allow the brightness of the central part of the fitting to be 1,500

ft.-lamberts, provided that the average brightness does not exceed 1,000 ft.-lamberts and that the brightness is graded from the centre to the edges, which should not be more than 30 times the brightness of the background.

The same point can be made on the brightness ratios of all the surfaces within the field of view. Too little contrast can be nearly as unsatisfactory as too much, but in a different way. We all know the lecture hall in which it is nearly impossible to keep awake continuously, however interesting the subject or the speaker. Judging American schools by photographs it seems that they suffer from too little variation of brightness. While visual conditions in the limited sense are no doubt excellent, it is hard to believe that some of these rooms give much help to the teacher in firing the imagination of the children, or in stimulating the children to creative activity. It is unfair to judge only on the evidence of photographs, but the fact that these are published in support of the methods used in their design is significant. It may be wise to sacrifice at least some of the "Brightness Engineering" to achieve articulation of the surfaces of the room and to obtain some modelling of the contents. Many architects are in agreement with this point of view and therefore a more flexible approach is justified at present. Recent work(9) shows that the rigid limitation of brightness ratios is not necessary if discomfort is to be avoided; more positively, some "sparkle" and the absence of monotony can increase the comfort. This does not, however, imply any challenge to the principles that the brightnesses of work, source and general environment must be controlled in relation to each other and that the transitions between different brightnesses must be carefully graded.

(6) Fittings

If the whole environment is to be adequately lit, with the work slightly brighter than the rest, it seems likely that at the present time most school lighting will rely on fittings of the semi-direct diffusing type. The aim should be to get as much light as possible directly on to the working plane while getting enough on to the ceiling and the upper parts of the walls to keep the contrasts within bounds. In practice this will mean that the light output of the lamp must be directed approximately equally up and

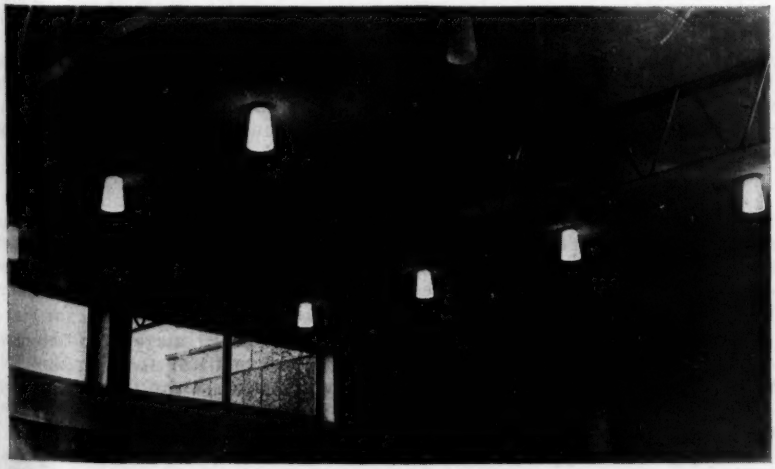

Fig. 4. Small tungsten lamp fittings suitable for use in classrooms

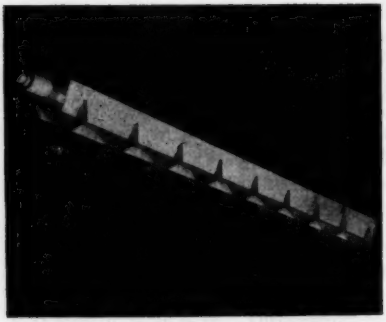

Fig. 5. One of the simple fluorescent lamp fittings developed by the B.R.S.

down by the fitting. If in addition the cut-off angle and the surface brightness of the fitting are right, if the fitting is neat and well designed in appearance as well as in performance, if it is not an unduly obtrusive feature of the room either in use or out of use, and if it costs a few shillings instead of several pounds, the client and the users are well on the way to getting a good and suitable job.

It may seem that this list of requirements is a steep one, but it is not impossible of fulfilment if tackled in a determined and rational way by everyone concerned—the illuminating engineer, the architect, the manufacturer, the wholesaler and the retailer. The potential demand for an adequate small fitting for use particularly in schools is great enough to justify an effort to produce it. (Fig. 4.) The reasons already mentioned will tend to encourage the use of lower ceiling heights, and that will mean more fittings than are usual in classrooms, and that the normal fittings will not be suitable. More and smaller fittings will make some aspects of the lighting problem easier to solve (and incidentally facilitate selective switching so that the artificial lighting can be used to supplement daylight more effectively), but they will increase the cost unduly unless this aspect is borne in mind all the time from the start of any scheme. For instance, in the development of new methods of building schools the wiring must be considered, together with all the other services, as an integral part of the system if the most satisfactory technical and economic solution is to be attained.

Fortunately, the acute Continental controversy about the suitability of fluorescent lighting for schools has not spread to this country, so that its use in appropriate circumstances is likely to increase. Architects will welcome this development more readily if experience leads to simpler fittings. The slim and elegant fluorescent tube seems to have a fatal fascination for louvres, panels, frames, egg crates and what-nots. The architect is normally not at all clear on their respective contributions to the quality of the lighting, but is very much aware of the difficult design problems arising from the often cumbersome fittings which result. There may be good reasons for this seemingly unnecessary complication, but it would be interesting to know in what ways, if any, the simple fittings devised by the Building Research Station (Fig. 5) fail to satisfy the requirements of modern practice.

(7) Decoration

Finally, it is essential to appraise the relationship of the decoration of teaching rooms to the lighting. Illumination is not, of course, the only factor which the architect must consider when deciding the colour and other properties of the finishes and furnishings; but the relationship between lighting and decoration in their effect on the environment is generally appreciated by architects, if somewhat vaguely.

Interest in colour in schools is increasing, and the bolder use of it is becoming common. The time is past when colours were chosen primarily for their dirt- and blemish-concealing properties, but this increasing freedom means that the lighting and the decoration must be carefully considered together at an earlier stage of design than is general at present, and by architect and illuminating engineer together.

Ceilings, and the upper parts of walls where these form part of the background against which light sources will be seen, should have a reflection factor carefully

chosen in relation to the known brightness characteristics of the fittings. The upper parts of the walls should not be much less bright than the ceiling, the object being to achieve a reasonable grading of the brightness of the fitting and its surroundings. General lighting fittings demand a reflection factor for these surfaces of the order of 65 per cent. or over.

Walls should have reflection factors of 45-70 per cent., depending on their position and use. For instance, the "back" wall (opposite the main wall, and often under a clerestory window) can well have a factor of 60-70 per cent., while that around a chalkboard will be more satisfactory if the reflection factor is 45-55 per cent., with the chalkboard itself 15-25 per cent., depending to some extent on the colour. Floors and furniture should have a reflection factor of about 30 per cent., a value typical of many natural wood finishes. The mention of furniture raises one other point; horizontal surfaces should never have glossy finishes if trouble from specular reflection is to be avoided, especially when the source is a large one.

This last point justifies a final affirmation of the importance of understanding co-operation by all those who are concerned with school. The selection and specification of furniture is often outside the architect's control; it is a matter for the Authority's Purchasing Officer or just "someone in the Education Department." Good lighting in its true sense calls for the full co-operation of everyone concerned with the school —the administrator, the teacher, the architect, the engineer, the supplier, and the maintenance staff. To persuade them all of that truth is the first step towards good lighting in schools.

References

(1) Johnson-Marshall, S. W., Proceedings of the Building Research Congress, London, 1951, Division 3.
(2) The Standards for School Premises Regulations, 1951, No. 1753.
(3) American Standard Practice for School Lighting, 1948. (Sponsors: Illuminating Engineering Society, American Institute of Architects). American Standards Association, Inc.
(4) Hopkinson, R. G., Trans. Illum. Eng. Soc. (London), **14**, 244 (1949).
(5) Biesele, R. L., jun., Proceedings of the Building Research Congress, London, 1951, Division 3, 142.
(6) Hopkinson, R. G., J.R.I.B.A. **59** (to be published).
(7) Petherbridge, P., and Hopkinson, R. G., Trans. Illum. Eng. Soc. (London), **15**, 39 (1950).
(8) Allen, W. A., and Hopkinson, R. G., J.R.I.B.A., **58**, 222 and **58**, 272 (1951).
(9) Hopkinson, R. G., Proceedings of the Building Research Congress, London, 1951, Division 3, 133.

Discussion

MR. C. W. M. PHILLIPS: I would like to take this opportunity of paying a public tribute to the work of British architects during the last few years in the design of schools. I live in Hertfordshire and have had an opportunity of inspecting many of the new schools built within the last two or three years in that county. They are truly wonderful places for children to grow in, and it would appear from some of the illustrations given by Mr. Pott that the same high standard of design prevails in most other parts of the country.

Some few years ago I made a survey with one of my colleagues of a series of schools built before 1914. The headmaster of one of these schools felt very strongly about the appalling interior decorations, to say nothing of the lighting, and we generally agreed that one could hardly expect the average British child to develop any deep appreciation of good things if he or she were to be brought up in an atmosphere which

was so completely soulless. It would be very interesting to ask Mr. Anthony Pott to consider the preparation of a further paper, which indicated what might be done with lighting and interior decoration to change at least the internal characteristics of some of these old schools.

Mr. Pott referred in his paper to the fear that lighting engineers might attempt to dictate colour schemes in their desire to control the brightness distribution in a classroom. I do not think there is any fear of that. All the brightness engineers want to do is to make sure that the reflection factors of the various surfaces in the field of view are controlled within reasonable limits. The establishment of such a specification is, I think, part of the lighting engineer's responsibility, but the precise colour treatment within this framework should be left to the architect or artist, who is, I am sure, much better able to do it.

I was a little sorry to see such a sharp division between natural and artificial lighting. Our President in his Address last year reminded this Society of the importance of natural lighting, but I would like to see two apparently conflicting lighting methods brought together in the building design stage as a common lighting problem. It is wrong to regard artificial lighting purely as a matter of fittings design. Just as a wall appears to be the natural place to locate the window, which is virtually a natural light source, so the ceiling has, by tradition, become the natural place for artificial lighting; I would like to see as much attention given by architects to the design of the ceiling and the artificial lighting as one problem as they are giving to the design of the window wall. The fluorescent lamp gives us very considerable opportunities for treatment of the ceiling as a light source and one has noticed the tendency in America for "louverall" ceilings, which bear a considerable relationship to the venetian blinded window.

Nowadays in modern schools we should be able to assume that there will always be a sufficient number of lumens per square foot on the desk and we should, therefore, be able to turn our attention a little more towards the use of natural and artificial lighting for creating the ideal educational environment.

MR. M. HARTLAND THOMAS: Before I read Mr. Pott's paper I considered what were the things that I thought I knew about the problems of school lighting, and I felt I had a few ideas. Then I read the paper. One by one Mr. Pott quietly and confidently anticipated all my points, finishing when he knocked over the little problem on specular reflection. Nevertheless, I think this problem is one that I might start on. He says that we must avoid specular reflection from the surfaces of school desks. I do not know of any suitable dull coloured durable finish for a desk or table that is not going to raise that problem. Illuminating engineers might get at manufacturers of tables and desks and point out to them that when they spray the table with cellulose it reflects all sorts of things, and irritates the eye. I wonder if some of these "leathercloth" tops would do.

I was very glad that Mr. Pott introduced the idea of sparkle—that you do not want an all-over, even illumination. Anything that sparkles directly in the line of vision where you are directing your attention to your work must be barred, but when you raise your eyes from what you are doing and look around to relieve both the eyes and the brain, then some sparkle is wanted. A development of this idea is that variation in lighting can be used most helpfully to support variation in the use of a classroom. We have just had it very-well pointed out to us that every room in a school needs to be a multi-purpose room, involving not only a change from one single purpose to another single purpose, but allowing four or five or more different things to go on in small groups all over the room. Here is an opportunity for clever illumination. If you can get, either by artificial light or natural light, a pool of illumination where you place the little group of people working, how easily and tactfully you concentrate their attention and form the group! It is a problem in applied

psychology. Cleverly disposed lighting, whether natural or artificial, can be very helpful in promoting those advances in teaching that we have been hearing about.

The low-ceilinged classroom requiring, as it does, a greater number of small powered lights tends towards the sort of arrangement I have just described. The clever use of skylights again, as Mr. Pott suggested, not in long lights but small separate ones, can do the same kind of thing. Imagine a room in which the average illumination—either natural or artificial—was not very high, but in which there were pools of light, at points in the room, coming perhaps from skylights, clerestory windows or from individual electric lights. There you would have variety in illumination, but a variety controlled to certain extent. You might well have adjustable blinds to the skylight and individual switches to the lamps, so that the lighting could be used as an instrument in support of the teaching.

Talking about skylights makes one utter a warning. They can be extremely awkward and ugly. I was not happy with one example we saw on the screen; deep girders ran across the skylight and the ceiling was sloped up to it. The whole effect can very readily be overpowering up in the roof. I know that normally as one sits in a room one does not look directly at the ceiling, and therefore, perhaps, complexity up there is not as awkward as it would be elsewhere, but nevertheless I am a great advocate of the quiet and unobtrusive interior as a background to one's occupation. In fact I feel that most architecture should be regarded as a quiet background to people's lives. In a schoolroom one wants to avoid these extraordinary shapes that one gets in the roof and that are so often due to the theoretical approach to the standard of illumination at the working surface. I think Mr. Pott refers in the paper to the ideal sectional shape of a classroom with its side windows, roof light and so on, as complicating the structure in order to get as straight a line as possible in the curve thrown across the section showing the degree of illumination at the working plane. Whilst being an advocate for the use of skylights to distribute the light in a straight and convenient manner across the room, I am not a whole-hearted advocate of anything you choose to do with the skylight—they are very tricky things.

Another point is the gradations of light around windows in modern construction. I think we have a very difficult problem there. Recently attention was called to the way in which the Gothic church builders and the Georgian domestic builders would design a reveal to a window with suitable splays and mouldings giving a gradation of light from the darker interior towards the light coming in at the window. We appreciate this solution and are well aware of the problem, but these methods are not open to us in the type of construction we have been looking at to-day because the modern wall is so thin. You do not have the thickness of wall which would accept a splay of any reasonable dimensions. Where our forefathers had three feet we have three inches or less. We must, I think, tackle the problem in a different way. The use of venetian blinds and curtains has been mentioned, and also the use of fins and shades outside; they were referred to as something that is, perhaps, too expensive and rather out of fashion. I would like to suggest more consideration is given to another method—the use of different kinds of glass as one progresses from the dark interior to the clear glass window.

The use of glass blocks as an intermediary between the clear glass has been tried but I see in Mr. Pott's paper that these are losing favour. I think the reason is that although these prismatic blocks grade the light, when the sun is at certain angles they tend to be a source of glare. We saw one example where there was a large window and just a band of blank wall; that occurred once or twice in the assembly hall, sometimes in the classrooms. I should be interested to see that band of blank wall carried out in a translucent glass; alternatively, the marginal panes of some of these big windows might well be made of glass that did not transmit as much light as clear

glass, thereby easing the eye from one to the other. Another possibility is that the upper part of windows that are needed to get a good angle of light back in the interior of the room might carry some type of louvre in themselves.

A new type of glass, developed in the United States, may prove of interest. It is much the same as the "egg-crate" which we know so well as a controller of light; a 3-16-in. square egg-crate of opal glass is contained within the thickness of a sheet of ordinary clear glass. A glass of that character could be extremely useful in cutting off direct sunlight where you want to do so, and yet allowing direct light and vision at the chosen angle. Apart from that particular glass, which seems to me to have possibilities, I wish to advocate the use in windows of gradations of different kinds of glass, because this might be more economic than having venetian blinds and curtains and might also give an assured standard of comfort without having to rely on the human factor.

I spoke earlier about the use of artificial light and natural light in skylights and ceiling lights to control the illumination of the whole room, and I hope I found favour with you in speaking of the two kinds of light together like that, but if you are going to use them together there is the problem of colour. I do not know whether I am over-sensitive in this, but I find that when I turn on electric light to supplement daylight towards the end of the day, the difference in colour between the two kinds of light is irritating and distracting. If you are supplementing daylight with artificial lighting, clearly it is better to use fluorescent light. If, however, your scheme is based to a large extent upon the permanent use of fluorescent light—the windows being hardly more than windows for view—I am inclined to think that very often the illumination from the fluorescent lamps is inadequate.

Finally I would like to repeat Mr. Pott's question about that little B.R.S. fluorescent fitting. Why does nobody take it up? I have tried to interest manufacturers in it and I do not know what is wrong with it. It seems to me to be just the right sort of thing. Is it perhaps too simple?

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MR. J. J. CHAPPAT: In his excellent paper on the lighting of schools Mr. Pott has referred to the acute controversy in France about the suitability of fluorescent lighting for schools. May I bring you more information on this subject? Two years ago the French Ministry of Education issued a new code on school furniture. In the chapter devoted to lighting, the use of fluorescent lamps is forbidden and recommendations are made to use semi-indirect fittings with incandescent daylight lamps. No reference is made to any level of illumination nor, as you may imagine, to permissible brightnesses in the visual field. Following a request by the President of the Association Française des Eclairagistes to the Ministry of Education, it was decided to undertake a series of tests in a high school and two professional schools. The schoolrooms chosen were those where pupils had to perform work every evening under artificial light. One room, which acted as a control, was lighted with incandescent lamps in diffusing globes. The illumination level varied between 2.5 and 4 lm./ft.^{2}. Two other rooms were equipped with incandescent lamps in diffusers at an average level of 10 lm./ft.^{2} and four others with different types of fluorescent luminaires with 40-watt, 4 ft., white lamps. The average illumination in these last four rooms varied from 12 to 70 lm./ft.^{2}. This high level was obtained on the visual task on sewing machines. The number of pupils in these rooms was 28 to 37 in the high school and 12, 17 and a maximum of 20 in the professional schools. The pupils' eyes were examined in October, 1951, at the beginning of the school year. They had another examination at the end of the period when they had been working every evening in artificial light. Results are not yet published and I, therefore, regret being unable to give them. It would be of great interest to me to know if similar tests have been undertaken in

Great Britain and what were the results. This might enable a fruitful comparison to be made when our results are known.

MR. A. G. PENNY: Observing during this conference the enthusiasm with which the audience as well as the speakers have joined in this controversy on comfort or absence of discomfort, it has seemed to me that on occasions the enthusiasm for the game has rather overun the ball. Mr. Kalff pointed out that in the 1900s only small local lighting was possible because of the high cost. If we had attempted at the beginning of this century to achieve modern standards of lighting, it would have required a considerable percentage of the manpower of the working population to raise the coal, produce the electricity, etc., and this is clearly the reason why only small quantities of light could be used. In the last twenty years the cost of lighting has been reduced considerably, and lighting engineers can now plan proper lighting for easy seeing. Speaking generally, it seems to me that the planning of satisfactory conditions for easy seeing is no longer a major problem. We can choose the simplified conditions of lighting advocated by Mr. Logan, or the more complicated but somewhat rigid system recommended by Mr. Kalff, or the rather more flexible plan favoured by some British lighting engineers, but I think it unwise to get too involved in a controversy on which is the best system, because it seems to me that they are not truly comparable. Mr. Logan is mainly concerned with a system which suits the American market where distances are large and the possibility of personal contact and instruction is limited. In this large field the erection of many averagely good installations is more important than the creation of a masterpiece by the individual super lighting engineer. We should, I think, begin to look into the future and try to see what can be done with lighting when it becomes even cheaper than it is to-day. I think Mr. Pott and Mr. Hartland Thomas have given us an idea. They have pointed out that there is now the possibility of using light not only for seeing, but for doing whatever task we may have to do. They have taken the example of the schoolteacher and have shown how lighting can be used not only to help the teacher and the students to see, but how it can be used to help the teacher to teach and the student to learn. In modern shops the lighting schemes are designed not only to light the goods, so that the customers can see them, but also to help the goods sell themselves; thus lighting has become a tool for the schoolteacher and a tool for the shop assistant, and I think that we may very well see in the near future a greater use of light not merely for seeing but for helping people in their daily tasks, and in that way contributing to an increase in the general level of productivity.

MR. J. STUDHOLME: The only section of the paper I am really interested in is the section on lighting fittings. Mr. Pott throws out a challenge on a particuar design of fitting which was again brought to our notice by Mr. Hartland Thomas. I wonder just how much of his tongue the author had in his cheek when he threw out the challenge. Mr. Hartland Thomas has told us that this particular fitting has been taken round the fittings industry with very little success and I rather feel that this answers the challenge.

I would like to add my own opinion that the fitting referred to has hardly reached what the fittings manufacturer would consider the prototype stage. It requires a lot of development before it could be considered a practical lighting fitting, as there is considerably more to fittings design than mere shielding of the light source or producing a pleasing external appearance.

MR. W. BOISSEVAIN: I think, in defence of Mr. Pott, we should say that the B.R.S. fittings have been designed in a very simple form, primarily as a reaction against many of the very large and over-elaborate designs of fluorescent fittings on the

market to-day, but perhaps in doing this they have gone too far towards the other extreme.

I believe the basic approach is the correct one, but I would make four criticisms of this fitting, which should be regarded as a prototype.

First the construction is such that the suspension rods can be placed only at the extreme ends. This, I feel, is an unfortunate feature.

Secondly the unit has been designed for use with a 5-ft. 80-watt lamp and this particular form of construction does not allow the use of other sizes of lamps using bi-pin lampholders instead of the B.C. lampholders of the larger lamps; modifications are therefore necessary if a range of different sizes is contemplated.

Thirdly, the control gear is housed away from the fitting. This is undesirable for many reasons, as not only does maintenance become difficult, but also unpleasant bulky housing must be provided on the ceiling. The design of fluorescent fittings is made more difficult when the control gear is incorporated within the fitting, particularly when bulky gear is used, but, nevertheless, I believe that a successful design must allow for housing the control gear within the fitting. One should avoid the temptation of using the very slimmest control gear without having ascertained that the consequent higher running temperature will not cause trouble. I would agree with Mr. Pott that there is a most definite advantage in making fluorescent fittings simple and small, but this should not be achieved by sacrificing other important factors. The Swedes I believe, were the first to produce a simple small unit with glass or acrylic sides, and there are manufacturers in this country who are making comparable types.

Finally, in the B.R.S. fitting I consider that insufficient attention has been paid to the ends, and I believe that this is probably the most critical part of a fluorescent fitting. The solution seems to be to use a very simple form produced by a high standard of workmanship to give a precision effect, and then pay great attention to the final finish. A simple metal end with a first-class finish looks much more satisfactory than many of the complex designs that are on the market to-day.

MR. S. S. BEGGS: Although I have a large number of questions to ask the author, I would emphasise that I agree with him fundamentally and disagree only in matters of detail. I would approach the subject from the points of view of the parent, the teacher, the ratepayer and the lighting engineer, of all of which I have some experience.

Mr. Pott's illustrations of classrooms showed mainly those of the less formal lay-out adopted for many recent primary schools. I am not sure whether he thinks such informality is equally desirable in secondary schools. Even for primary schools the schemes and arrangements described for group working are rather ideals, where space, equipment and staff are plentiful. Do they work well and are they economically practical under present conditions? Is it not better to aim at the practical which works, than at the unattainable ideal which only adds to the burden of the teacher? Mr. Pott also advocated the classroom opening straight on to the garden or playground. I dislike this idea, for (from experience with my own son) I think children need a certain amount of formality and discipline right from an early age, and the study areas should not be loosely mixed up with the relaxation areas.

Mr. Pott said he thought we needed to increase our skill a great deal before we can use illuminations higher than 10 lm./ft.^{2} in schools. As such higher illuminations are used satisfactorily elsewhere, does he consider that need to apply to all installations, or are there particular problems related to their use in schools?

Regarding the specialisation of rooms, such as the assembly hall, we should consider the *need* for such an arrangement. If a hall is desirable on wide educational grounds (e.g. *esprit de corps*), the period of use should not be a measure of its value to the school. In a cinema, for example, only about 5 per cent. of the light from the projection source reaches the screen, but we continue to use cinematograph pro-

jectors as they are the only means of obtaining the effect we desire. Correct lighting for each room should be provided, and the authorities must be convinced that if requirements clash, compromise is a false economy.

Mr. Pott said he had come across a few school installations that were well lighted "probably by luck." Is no credit due? I also understand him to say that the photographs he had seen of school installations designed according to the tenets of illuminating engineering were all really rather bad. Surely the first tenet of illuminating engineering is that the final installation must be acceptable?

I am rather alarmed by the move towards the designing of lighting fittings by architects, for the same reasons that architects would not like the lighting engineer to design the ceiling to support his fitting. I do not believe that there is a scarcity of satisfactory lighting fittings for tubular fluorescent lamps, and I do not think that Mr. Pott could have looked very far if he found none that was essentially the same as those shown by him. He asks in particular why nobody has liked the design illustrated. Speaking personally, I do not like it very much for school lighting because its appearance is too "utilitarian," and has not sufficient decorative appeal. The principle of the design is sound, but I do not think the embodiment is quite suitable for a school, which is a cultural institution.

MR. S. ANDERSON (*communicated*): It may be that there are others who, like myself, are ignorant of the way in which the "Standards for School Premises Regulations, 1951" are applied. I should be grateful if the author would indicate to what extent they are mandatory, or whether they are regarded more as a guide to good practice subject to local interpretation.

In Fig. 4 of the paper, for example, the artificial lighting shown does not look as though it would be adequate to provide 10 lm./ft.^{2}, nor do the shades appear to be sufficiently large to keep the surface luminance within the 1,000 ft.-lamberts prescribed, nor within the maximum of 1,500 ft.-lamberts suggested by the author.

Another contributor to the discussion has suggested that beams standing out from the ceiling are undesirable. While I would not presume to join issue with him architecturally, as a lighting engineer I would draw attention to their usefulness as concealment for light sources. For instance, the pendant trough fitting for chalk-board lighting shown in Fig. 2 could, I think, have been dispensed with in favour of a fitting mounted higher and at least partially concealed behind the deep beam shown. In this position the light source would be less liable to give a specular reflection visible to the class from the board.

The author has referred to the need for supplementary windows, sometimes provided by a clerestory, to improve the illumination in classrooms at the side remote from the main windows. I would welcome his opinion as to whether this supplementary lighting may be given more economically by the use of fluorescent lamps suitably positioned. It must surely add materially to the cost of any but the smallest school building if windows are provided on two opposite sides of classrooms.

Lastly, I was delighted to see Mr. Pott's reference to fluorescent tubes as "slim and elegant," and I hope that he will be successful in finding fittings for them, from among the wide range already available, about which he will feel able to use similar epithets

MR. IAN S. PLUMTREE (*communicated*): In many of the papers presented at this conference, the emphasis has been on fundamentals, this one being no exception.

One of the elementary ways of improving visual acuity is first to utilise daylight to the greatest advantage, and secondly to alter or adapt existing mechanical arrangements wherever possible.

As an illustration of the above, I would cite the lighting in some offices of a

prospective client where I was asked to suggest what could be done to improve illumination at the working plane without installing new light sources or fittings. My first suggestion was that the illumination on the working plane could be increased by cleaning the existing dirty reflectors and fitting new tungsten lamps; secondly, I suggested that the typists instead of sitting with their backs to the windows should either face them or sit at 90 deg. to them so that daylight came from their left! I think that this latter principle could be applied to the room illustrated in Fig. 3 in the paper, where it appears that most of the children have their backs to the windows with the empty chairs facing the windows.

MR. A. POTT (in reply to the discussion): I agree whole-heartedly with many of the points which have been made in this discussion and I will not take up time in cataloguing them. I am particularly sympathetic to one raised by Mr. Phillips—the improvement of old schools, especially by redesigning the lighting and decoration. At present Local Education Authorities are having to concentrate their efforts on the provision of new schools to provide places for the increased number of children; I hope that before long the Authorities will be able to give some attention to the improvement of conditions in some of the older schools.

Mr. Hartland Thomas sounded a well-justified warning on some of the architectural problems raised by the use of top-lights; I was especially interested in his remarks on the need to find solutions to the problem of the relationship of window to wall which would be as appropriate to current building techniques and as functionally satisfactory as were some of the historical solutions. I would like to see his suggestions for the more adventurous use of glass with different transmissions worked out and applied in a school.

I regret that I do not know of any work being done in this country comparable to that outlined by Mr. Chappat. The subject is an important one, and I very much hope that when the results of the French work have been analysed they will be made generally available.

I should like to thank Mr. Boissevain for his constructive criticisms of the B.R.S. fluorescent fittings which I find interesting if not altogether convincing. I think that the B.R.S. would probably have counter-comments on some of his points.

In reply to Mr. Beggs's first question I would say that the less formal arrangements of general teaching rooms to which I referred are being increasingly used in secondary modern schools. I do not think that the teaching methods underlying them are impracticable or idealistic. It is true that a room for a secondary modern class of about 30 must have an area of about 600 sq. ft. if this kind of layout is to be used, compared with the Regulation minimum of 480 sq. ft., which can only be used for formal directional teaching with one set arrangement of the furniture. If the majority of the classrooms are increased to 600 sq. ft. it allows of their use for a much wider range of activities and of a reduction in the specialised rooms which are necessary.

I am sorry that I did not make clear my point about the minimum level of illumination laid down in the Regulations. It is generally agreed, I think, that the higher the level of illumination the greater is the skill necessary to produce good lighting in the full sense. Until it is reasonably certain that the lighting of every school will be skilfully designed (and until that time the element of luck may play a part), it would be inviting generally less satisfactory lighting if the obligatory minimum illumination were increased.

I think Mr. Beggs misunderstood me on one point; I hope so, for I certainly did not mean to imply "that the photographs he had seen of school installations designed according to the tenets of illuminating engineering were all rather bad." I think that this arises from the last paragraph in Section (5) of my paper. I was

referring to photographs of certain American schools designed with too great an emphasis, it seems to me, on the strict application of a system of limiting brightness-ratios. When Mr. Beggs says that an installation must be acceptable, I ask, "Acceptable to whom?" Presumably the lighting of the classrooms to which I referred is acceptable to the designers and to the authoritative body which made the recommendations on which the designs are based. They are not acceptable to me; and, in case that sounds presumptuous, I should add that they are not acceptable to most of the achitects with whom I have discussed them.

Finally, there is the matter of designing fittings. I think that this is a job calling for the co-operation of the architect, the lighting engineer and the manufacturer of fittings, and that each has a contribution to make. Mr. Beggs's analogy of the lighting engineer designing the ceiling is a fair one; I think that that, again, is a matter for collaboration of the same kind, as I agree with Mr. Phillips that the ceiling and the artificial lighting should be considered as one design problem.

The answer to Mr. Anderson's question about the Regulations is that they are mandatory. The school illustrated in Fig. 4 of the paper was designed before the present Regulations came into effect. I did not intend to imply that the fittings shown in that photograph fulfil all the requirements; I showed it to give an idea of the kind of fitting which architects are tending to use because more satisfactory ones, considering *all* the requirements, are not available. Mr. Anderson's point about the blackboard light and the beams, emphasises the need for collaboration between all the designers concerned.

I have no contribution to offer on Mr. Anderson's point about the economics of supplementary lighting by fluorescent lamps instead of by windows, except to say that the problem should be investigated. If it can be authoritatively established that fluorescent lighting is a satisfactory substitute, physiologically, for natural lighting it seems to me to be an architectural and economic problem, and a complicated one. For instance, the comparison of cost will be significantly affected if it proves necessary to install mechanical ventilation for rooms with windows on one side only.

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The Design of Interior Lighting Equipment

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Summary

The object of this paper is to record major developments in interior lighting equipment and in so doing to indicate the direction in which future developments are most likely to move. A short section is devoted to fittings in general use up to 1940 when the first impact of the fluorescent lamp was felt. The effective use of high-pressure mercury vapour lamps is considered and the value of horizontal burning lamps is emphasised.

After discussing some of the problems in the design of standard fluorescent fittings, with a particular reference to the complication caused by the many different types required, brief analyses are given of the lighting units required for some special types of installation.

For example, in a power station, the crane rail may be used as the main rigid structure for fluorescent lighting fittings built around it: commercial fittings have also been designed on this principle. Another interesting technique uses composite fittings of metal and plaster, since plaster can be formed easily and cheaply to a desired curvature.

The author believes that fundamental changes are now taking place in the mechanics of lighting practice, which may have a far-reaching effect on fittings design, but that progress may be hampered by too great complexity. Advances in lamps are inevitable and desirable, but every effort should be made to rationalise the design of lamps and components to assist the fittings maker in reducing some of the many variables in his equipment.

(1) Introduction

While this paper is not intended to be historical, it is desirable to create a background against which the modern developments of interior lighting equipment may be viewed. For this purpose, the first section deals with fittings in general use before 1940, when the fluorescent lamp came into prominence. The design of standard fittings is then discussed, and finally examples of special design are dealt with in some detail as it is thought that the key to the future of interior lighting may be found in these more special projects.

(2) Historical

It is little more than ten years since the majority of interior lighting fittings consisted either of vitreous enamelled circular-steel reflectors, or of opal and prismatic glassware of varying design. On the whole, light distribution was the keynote of design, coupled with efficiency and safety. By 1937 a sound range of industrial and commercial tungsten lamp fittings was available. These fittings have stood the test of time and do not appear to be capable of much improvement. Architectural lighting was largely by laylights, plaster coves and cornices, and by ornamental glassware illuminated either by bare lamps or by lamps in industrial reflectors.

It is not proposed to discuss domestic fittings since there has been no material change.

Between 1937 and 1940 there was a lull in interior fittings design, marked principally in the author's recollection by the introduction of an acrylic plastic bulkhead fitting and an acrylic plastic dust-cover for vitreous enamelled fittings used in sugar mills. This may, incidentally, have been one of the first applications of acrylic plastics to lighting fittings in this country.

The author is with the British Thomson-Houston Co., Ltd. The manuscript of this paper was first received on February 8, 1952, and in revised form on March 29, 1952. Paper presented at the I.E.S. Summer Meeting at Eastbourne, May 23, 1952.

(3) The 250/400-watt H.P.M.V. Fittings

It was, however, during this period that the 250- and 400-watt mercury vapour discharge lamps were first applied to interior industrial lighting. The deep 20 deg. cut-off vitreous enamelled fittings used with these lamps were a natural development of standard tungsten lamp practice, modified to cope with the vertical operation of the discharge lamps. The light distribution from these linear sources, coupled with the difficulty of producing a satisfactory optical system for an arc some 6 in. in length, resulted in the light output ratio of these fittings in the lower hemisphere seldom exceeding 60 per cent.; depreciation, moreover, is severe with only small deposits of dust. It can be shown that only about 14 per cent. of the total lamp light output is emitted direct from these fittings, the balance being dependent upon the reflector.

Prismatic glass fittings, in which the lamps are used vertically, have similar characteristics, but have the advantage that much of the remaining light flux can be usefully employed in the upper hemisphere.

As early as 1937, magnetic arc control for these lamps was introduced, enabling them to be operated horizontally. The light distribution from horizontally mounted lamps is ideal for industrial application, for even when used in a fitting with a 20 deg. cut-off, 40 per cent. of the lamp light output is used directly, and the remainder can be efficiently controlled. This makes possible an overall light output ratio of 80 per cent. in the downward hemisphere; depreciation is relatively small.

Several types of horizontal fitting have been in operation for a number of years, and field experience confirms the theoretical advantages of horizontal operation. There are a number of factors in the design of fittings of this type to be considered, however, if the best performance is to be obtained.

Owing to the need for a magnetic arc control the reflector must be non-ferrous, and anodised aluminium is generally used.

In many heavy industries corrosive gases occur in varying concentrations, so that it is wise to make provision for cleaning and even renewal of reflecting surfaces. To meet this requirement the reflectors in these fittings may be made of quite thin aluminium, which can be easily removed and if necessary replaced.

The recent introduction of the MA/U discharge lamp, which can be operated in any position, makes the use of the magnetic arc control optional. As a component of a blended light unit (Fig. 1), these lamps have been extensively used in heavy industry. Fig. 2 shows a recently designed fitting based on the earlier type, and which may also be used as a component of blended light units of varying wattages. The one-handed removal of the reflector is demonstrated.

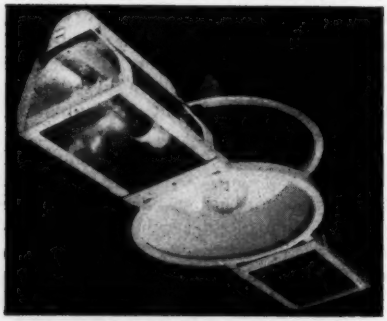

Fig. 1. Blended light unit with horizontally operated 400w. mercury lamps.

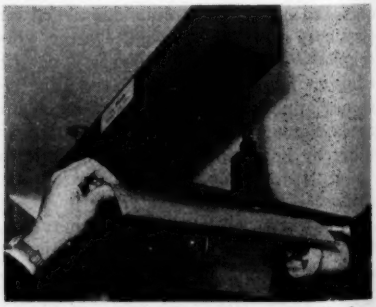

Fig. 2. Horizontal mercury fitting rationalised to accommodate 250w. or 400w. mercury lamps with or without magnetic arc control and to form the mercury component of a range of blended light units.

(4) Fluorescent Lamp Fittings—Standard Designs

(4.1) Some Problems of Design

The last pre-war catalogues show the tungsten fittings listed in the left-hand column of Table 1. These are the basis of the present-day standard range, and against each is listed, as nearly as possible, details of the equivalent fluorescent unit.

Table 1.

Pre-1939 fittings and their modern fluorescent equivalents.

Tungsten lamp fitting	Fluorescent lamp fitting
(1) Vitreous enamel reflector :	
(*a*) Dispersive	Open and closed end troughs
(*b*) Concentrating	,, ,, ,,
(*c*) Angle	,, ,, ,,
(*d*) Dispersive enclosed	Closed end troughs with glazed frames
(2) Diffusers (various)	Channel and other fittings with acrylic plastic or glass diffusers
(3) Flameproof	Flameproof and mines fitting
(4) Bulkhead and wellglass	—
(5) Trumpet-shaped and batten lampholders for bare lamps	Seagull and batten type fittings

Some problems involved in keeping a modern range of fluorescent fittings up to date may now be discussed.

It is perhaps not fully realised how many different fittings there would have to be to constitute a really comprehensive range, such that each fluorescent lamp normally listed could be matched with one or other of the four main types tabled in the previous section.

An analysis of the ordinary industrial trough fitting alone shows the variables given in Table 2.

Table 2.

Variables with fluorescent industrial trough fittings.

Variables	Number
Lamp ways One and two	2
Lamp wattages: 5ft. 80w.; 4ft. 40w.; 3ft. 30w.; 2ft. 40w.; 2ft. 20w.; 18in. 15w.	6
Types of reflector : Open end ; closed end	2
Reflector materials : Stove and vitreous enamel with or without upward light ; anodised aluminium ; opal acrylic plastic	6
Starting system : Starter switch ; instant start	2

Thus to complete this one range alone no fewer than 288 different fittings would be required, and this number is greatly increased if the range is extended to cover such additional factors as lead-lag circuits, channel or "control box on the top" types, slim line and cold-cathode lamps.

It is not suggested that all these fittings are stocked or even listed, but sooner or later a manufacturer will be called upon to supply quantities of most of these.

Thus, quite apart from meeting the dictates of application, appearance and, in

these days, availability of materials, probably the most important consideration in the design of standard fittings is simplicity and interchangeability of component parts.

For instance, all but the 80-watt lamp use the medium bi-pin cap, making possible common lampholder assemblies* for fittings equipped with five out of the six lamp sizes. Fittings may have either one- or two-lamp ways, and as a channel type of fitting will accommodate two sets of control gear, the lampholder assemblies should again be interchangeable in one- and two-lamp ways. These are strong arguments for the channel type of fitting, even though the elongated choke has been largely superseded by one having a larger cross section.

Lamps with medium bi-pin caps are, however, not so popular in this country as the 80-watt lamp with bayonet cap, which is an exception from the designer's point of view and a complication not experienced by our American friends.

The design of the B.C. lampholder assemblies has hitherto been the subject of debate, and has depended largely upon whether the demand for 80-watt fluorescent fittings exceeded supply or not. For maximum production, the somewhat untidy bare lampholder and lamp-clip method has much in its favour, but once the supply has approached demand, the competitive value of improved appearance becomes important, and the lampholder assemblies have to be tidied. This tidying necessitates sliding, or otherwise detachable, end covers, which not only take more materials and labour and therefore cost more, but can seriously reduce interchangeability of parts.

Fig. 3 shows one of several fixed B.C. lampholders, which help to make B.C. lampholder assemblies interchangeable with assemblies housing the bi-pin type holder. Incidentally, these new lampholders greatly simplify relamping, for not only can this be done from one end, but often with one hand, in the manner of the bi-pin type.

Thus far, it would appear that to meet the obligation to produce at least one fitting for each fluorescent lamp listed, there should be a standard backbone which can be cut to the required length, and fitted with interchangeable lampholder assemblies and end plates.

The fixing of the control gear is the next problem, and it is desirable that this should be a one-piece assembly which can be offered up as a single unit to the channel, just as in modern car assembly the motive power unit is offered up to the body and is held in place by only three or four bolts.

The fittings under discussion are of the industrial reflector type, but by making a back plate interchangeable with the reflector, a whole bare lamp range becomes available. The same principles can provide a series of decorative fittings.

(4.2) Stocking, Packing and Transport

Whether fittings are kept in manufacturers', dealers' or users' stores, they must be in good condition when the time comes for erection, and since they must occupy as little room as possible they should be designed to stack one on another. It is the designer's responsibility to see that these conditions are met. It would, for instance, be folly to design closed-end reflectors with vertical ends, since they will not nest one in the other; similarly a control box or back channel must be free from fragile projections and preferably should have no projections at all.

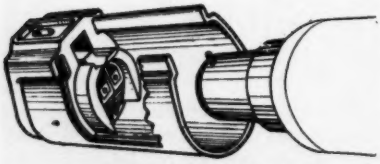

Fig. 3. A fixed B.C. lampholder.

*A lampholder assembly in this context refers to the lampholder and the associated metal base plate which may be an integral part of the fitting, or in some way may be detachable or made separately. Where loose lampholders are used it may include lamp clips and any covers or sleeves.

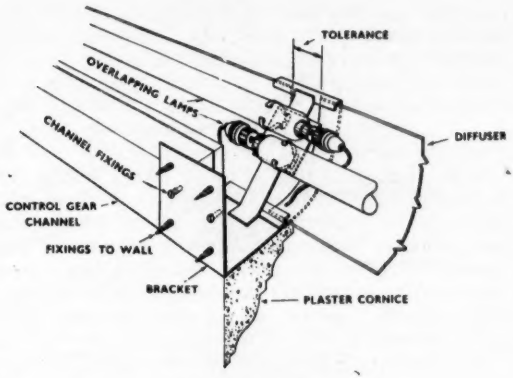

Fig. 4. Possible arrangement for a fluorescent cornice.

(5) Fluorescent Lamp Fittings—Non-standard Designs

Turning now from the problem of keeping up to date with the design of standard fittings, developments of less standard units can be considered. Although it is partly true to say that the "special" of to-day is the standard of to-morrow, fundamental changes appear to be taking place in the mechanics of lighting practice which may have a far-reaching effect on fittings design in the future.

(5.1) Fluorescent Cornice Lighting

This form of lighting is frequently valuable for decorative treatment of public buildings and calls for the exact filling of wall space. This can be done by introducing opaque brackets and by overlapping the lamps to form continuous luminous runs (Fig. 4). The brackets not only mask the lampholders, but also can be adjusted to make up the actual length. It is sometimes required to fill in between a series of pilasters, ostensibly the same distance apart, but in practice varying by an inch or more, making advantageous some tolerance in the cornice design. This also applies to opaque cornices where the overlapping of lamps is much less of a problem. Where lamps are overlapped in either type of cornice, white lampholders or white sleeves over them should be used, otherwise dark patches may appear on the adjacent wall.

Another form of luminous cornice is frequently used in the angle of the ceiling or on the sides of beams for the lighting of book shelves or control panels; this may be an enclosed fitting requiring a hinged or removable window. In this instance the building contractor is required to provide suitable fixing, and it is convenient for the fittings designer to specify this. Fig. 5 shows a typical construction which may be applied to any of the lamp sizes. Between each section a blank piece is fitted as necessary. Originally designed for straight runs, it can be used equally well for geometrical shapes such as the octagon in Fig. 6, providing that instructions for the framework are given to the building contractor. This design is very simple to construct, and all that is further required are suitable mitred corner pieces. When applied to control rooms, the emergency lighting can be catered for by arranging the tungsten lamps to protrude through the blank pieces. If pearl lamps are used the spill light from inside the fitting gently illuminates the extinguished bulbs.

(5.2) Crane Rail Lighting

A long, narrow and lofty room such as the turbine house of a power station is sometimes best illuminated by side lighting, provided that adequate measures are taken to avoid undue glare. In such buildings, the crane rails may afford the best location and means of support for continuous low-brightness light sources. The turbine house

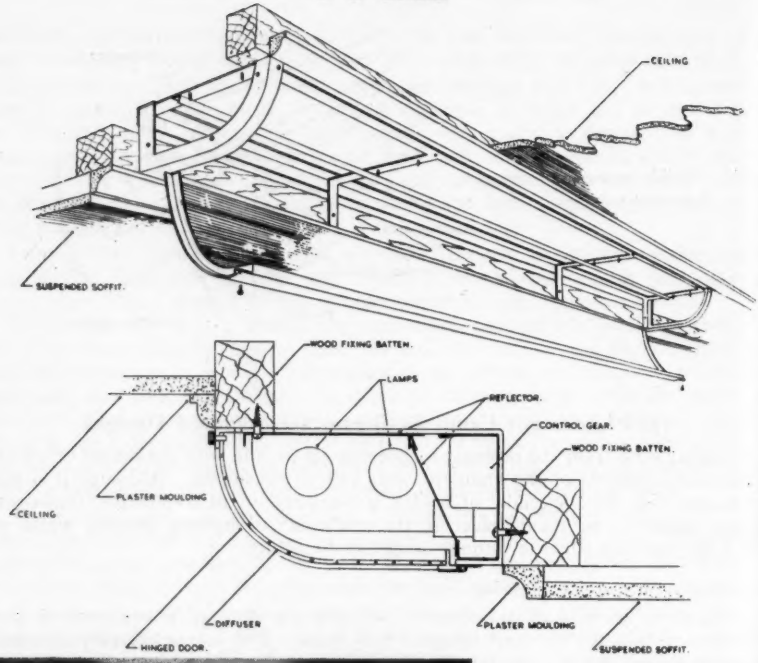

Fig. 5 *(Above)*. Alternate cornice arrangement.

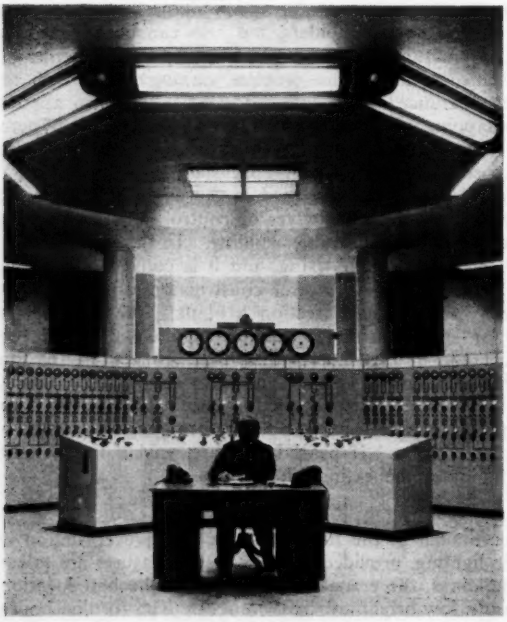

Fig. 6 *(Left)*. Installation with a specially built cornice in the form of a hexagon.

proper is sometimes open on one or both sides to boiler and electrical annexes, which can then be lighted if desired from the same positions. The terms of this design problem indicate a single- or double-sided angle fitting of continuous construction extending between piers or stanchions supporting the rails. Existing units vary from 18 to 34 ft. in length. Ideally the fitting should be glazed, and this requires window frames with openings sufficiently wide to enable 5-ft. lamps to be serviced.

No ordinary fitting complies with these requirements, so the crane rail itself is used as the main rigid structure of the fitting, which is then built on it. Fig. 7 shows a typical construction. The basic components are cast aluminium inverted "A" brackets clamped to the lower plate of the girder, or grouted to reinforced concrete beams. To these brackets are secured the three longitudinal members, two angle sections for the upper corners and a channel section for the lower corner. Control-gear trays are fitted between brackets, and rest on the flanges of the centre members of the "A"s; these trays also accommodate the wiring. Finally, sheet aluminium reflector panels are screwed into position between pairs of brackets. This completes the open type of fitting, which may then be glazed by the addition of a hinge rail and glazing frames.

The lamps are normally made to overlap, and the glazed fitting has a fully flashed and continuously luminous appearance. Installations include two and three lamp units with both single and double sides, glazed and unglazed. The same construction can be applied to fittings which depend on some other part of a building structure for their rigidity, and are too large to transport in one piece.

(5.3) Commercial Fittings Constructed on the Crane Rail Principle

Where it is desired to merge the daylight appearance of fittings into plaster entablature and to present long brightness patterns, uninterrupted by glazing bars, it is possible to butt the acrylic plastic or glass glazing end to end. Fittings up to

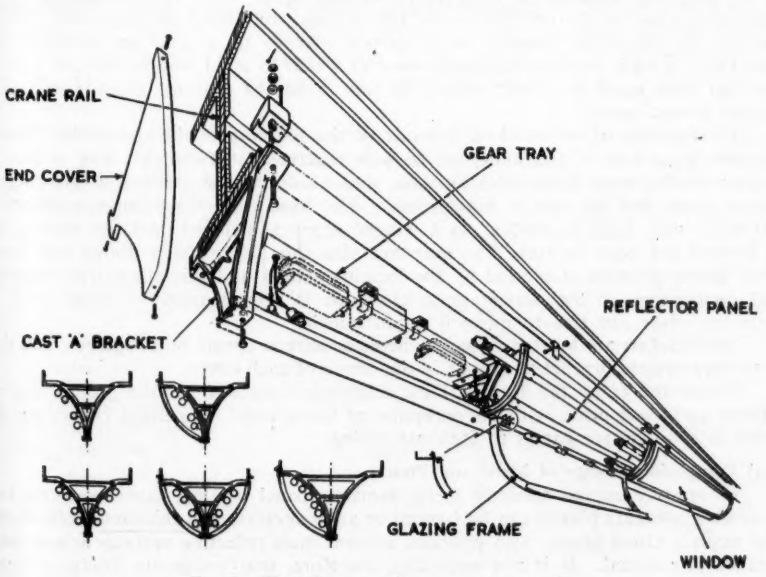

Fig. 7. Typical construction on to a crane rail.

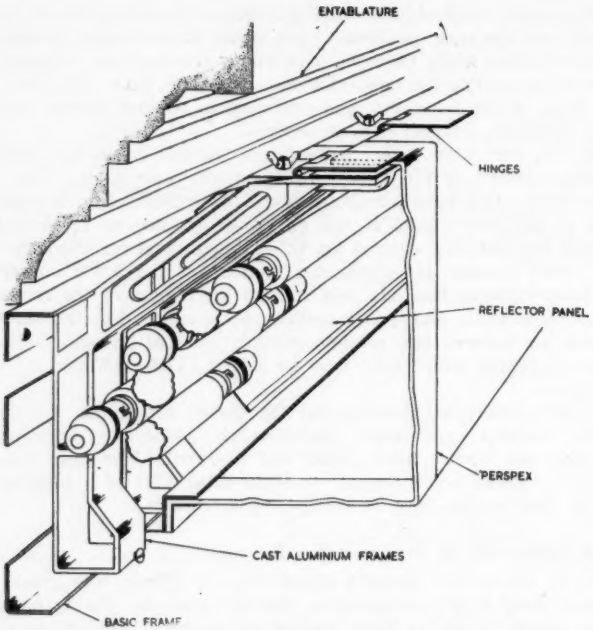

Fig. 8. Section of the basic frame for commercial fittings constructed on crane rail principle.

15 ft. long and housing as many as 12 80-watt lamps have been constructed by a method similar to that of the crane rail fittings, and fixed to brickwork through varying thicknesses of plaster. As it is not possible to depend on accurate fixing into brick, a basic framework is necessary on which to build, and to this are attached the cast aluminium brackets,* which, in turn, hold the reflector assemblies and the acrylic plastic covers.

The location of the brackets depends on the hingeing of the cover; this hingeing requires great care if the joints are to butt together satisfactorily. Fig. 8 shows a section of the basic frame and brackets, and illustrates the method of gripping the acrylic cover and the type of hinge used. The fixed part of the hinge is virtually a flat wide hook held in position by a winged screw and dowel, and the moving part is formed not only to take the cover but also soft felt packing above and below. Only gentle pressure is exerted by the locating screws and this allows for expansion and contraction of the acrylic material which is approximately 3/32-in. in 5 ft.; were the cover not free to move it might buckle.

The brackets are located in pairs where the acrylic covers butt together, and there is an intermediate bracket and hinge in the centre of each cover.

Unlike the crane rail fittings, these units are completed on the ground and are offered up in one piece, with the exception of the covers. Inspection covers are provided in the reflector panels to facilitate wiring.

(5.4) Composite Fittings of Metal and Plaster

To produce curved solids in metal demands panel beating, expensive press tools or casting, whereas plaster can be formed to any curvature and thickness both cheaply and easily. Good plaster also provides efficient matt reflecting surfaces whose maintenance is nominal. It is not surprising, therefore, that composite fittings of metal

*These have also been fabricated in steel.

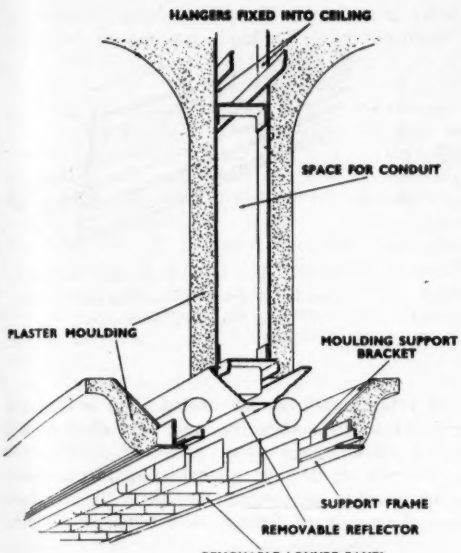

Fig. 9. Composite construction in metal and plaster.

and plaster should be employed where the design calls for such curvatures. Fig. 9 shows a section of a very fine installation constructed on this principle. This design comprises two large rectangles with rounded corners, and a central member of trumpet section also rounded in the horizontal plane at each corner. The lighting is a combination of direct louvred and indirect plaster cornice.

The construction employs a series of steel hangers spaced in pairs to form the wiring and control-gear channel, with the longitudinal members carrying the louvre and cornice system. Any number of patterns and designs are possible by this method, which adds greatly to the design engineer's repertoire.

(5.5) The Use of Extruded Aluminium and the "Tee-slot" Technique

Fig. 10 shows the construction of some very large fittings, some of which are one-piece units, 17 ft. long, where the main frames are formed of two extruded sections bolted together to form one external moulding. The corners are mitred and welded and the frames are supported by two or more cast cross members. Inspection of the actual section shows a platform for the control gear, a strengthening web along the top—which also locates the covers—and ribs along the bottom web to locate the louvres.

The wide variety of extruded sections and the comparatively simple tooling make this material one of the most useful known to fittings makers. The knowledge that fittings using this material nearly always require welding is sometimes used as an adverse argument, but in fact a skilled aluminium welder can make an excellent

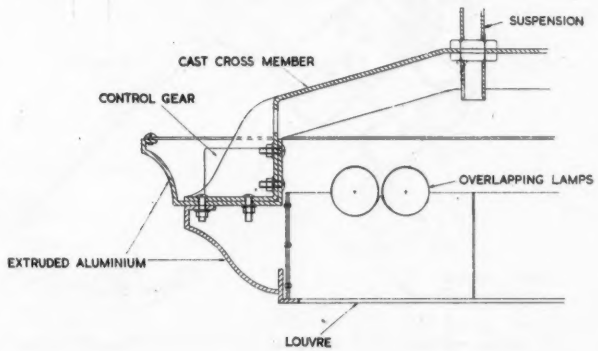

Fig. 10. Construction of a composite aluminium extruded frame fitting.

job quite quickly, so long as the alloy is chosen for both its extruding and welding properties.

Another section is shown in Fig. 11 which not only presents a pleasing exterior moulding but also houses the control gear, which may be fixed anywhere in the length without drilling. Fixing is achieved by a Tee-slot in the extrusion which will take the hexagon head of a 2BA screw, but will not permit it to rotate. The use of the extruded Tee-slot technique has greatly influenced design, and only the present shortage of aluminium prevents extensive developments.

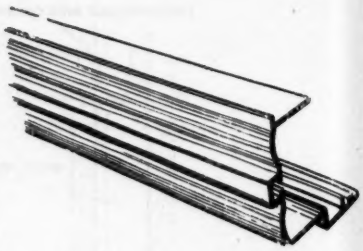

Fig. 11. Decorative aluminium extrusion showing "Tee-slot" for holding control gear and ledges for louvres, etc.

(5.6) Lighting Trunking

The practice of placing fluorescent fittings end to end started long before the introduction of channel fittings designed to accommodate the new slim chokes, and a special range of fittings incorporating cubic chokes was produced. With the introduction of the slim choke units, however, it became a simple matter to insert couplings and distance pieces of the same cross section and so build up standard fittings into a form of trunking. Many thousands of fittings have been so installed in this country in the last few years.

There has, however, recently been a development further simplifying such installations, the trunking now being extruded or fabricated in lengths up to 20 ft. or more as required. This makes it possible to eliminate as many suspensions as possible, to give complete freedom of location of the lamp and reflector assemblies and control gear, and to accommodate other services such as telephones, public address

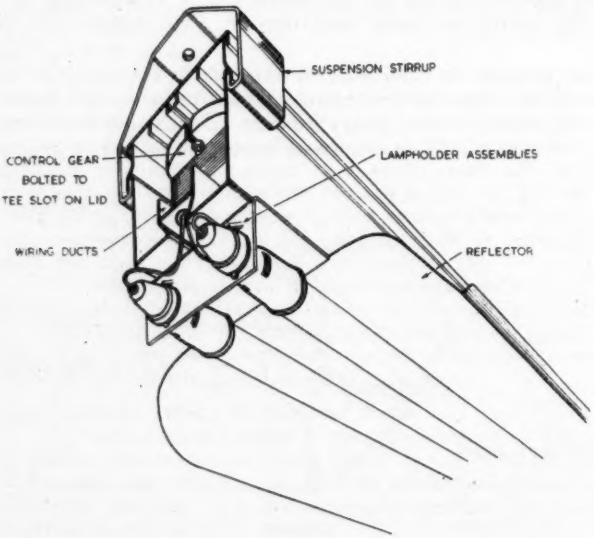

Fig. 12. Extruded aluminium trunking.

and visual signals. Fig. 12 shows an extruded aluminium trunking of this kind and Fig. 13 a cold rolled steel version. The Tee-slot technique is used in both, the slot in the aluminium lid permitting the control gear to be mounted anywhere in the run, and the dovetail in the bottom of the channel performing the same function for the reflector assemblies, clocks, loud speakers, etc. A further refinement is the provision of separate compartments for the various types of wiring. The trunking is suspended by stirrups engaging in the extruded hook section on the sides.

The steel trunking is very similar in operation, but has internal and external Tee-slots in the base of the channel.

To allow the wires to pass from the control gear to the lampholders, holes are punched at 2 ft. centres so that wherever a reflector may be located there will always be two holes behind it, thus concealing the wires to

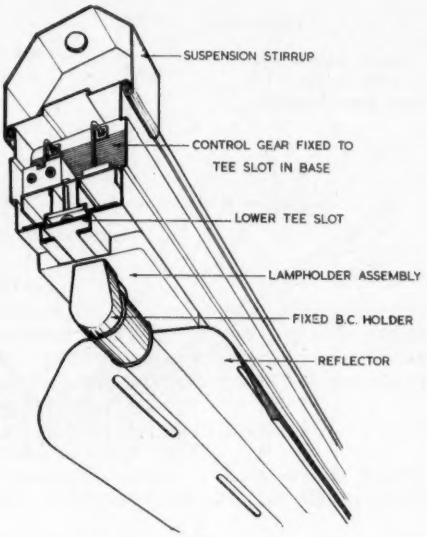

Fig. 13. Rolled steel trunking.

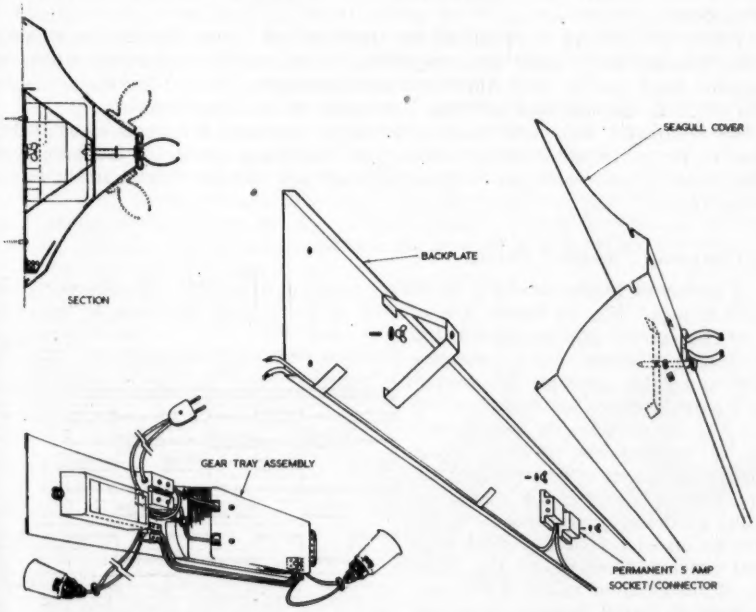

Fig. 14. Backplates of "Seagull" fittings to take one or two control gear assemblies.

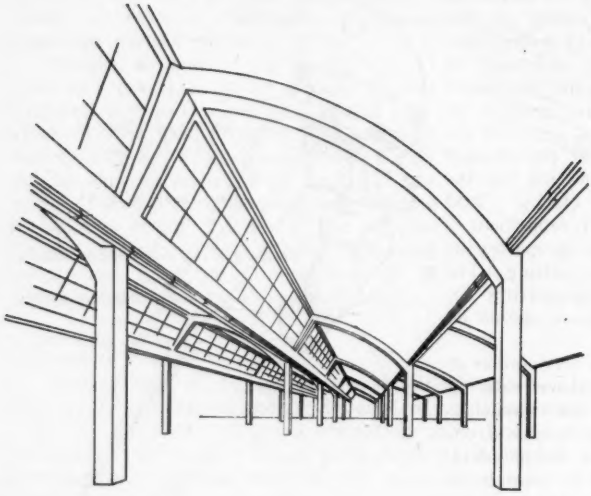

Fig. 15. Application of continuous "Seagull" fittings in a shell concrete building.

the lampholders. This universal type of trunking has very wide application in large factory areas, and enables the illumination to be changed with a minimum of difficulty and expense.

Where it is desired to install all the trunking and wiring but only a proportion of the reflector and control gear assemblies, as in very large installations, a large connector block can be used which can accommodate a pair of 7/.036 wires looped in on one side and can take a 5-amp 2-pin plug on the other side.

An installation with such connectors fixed at say every 6 ft., enables the lighting layout to be rearranged without shutting the installation down. A trunking system of this kind is truly universal in its application and can be very valuable in large factory areas.

(5.7) Continuous "Seagull" Fittings

A system of similar flexibility to that of trunking is possible with almost standard seagull fittings. Fig. 14 shows how a series of blackplates are made to take either one or two control gear assemblies; the main wiring is looped into a connector socket and each assembly is covered with a seagull section lid butted end to end. The lid provides for one or two pairs of lampholders, so that again without disturbing the wiring the illumination value may be varied to suit any particular application. Fig. 15 shows an installation in a typical reinforced concrete factory, and Fig. 16 a table of illumination values which can be derived from various uniform arrangements of lamps.

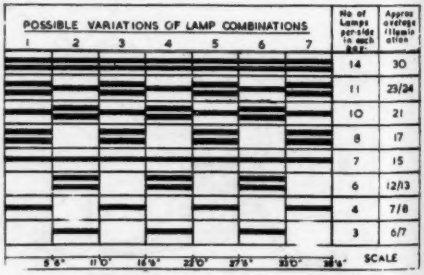

Fig. 16. Possible lamp combinations with continuous "Seagull" fittings and resulting illumination.

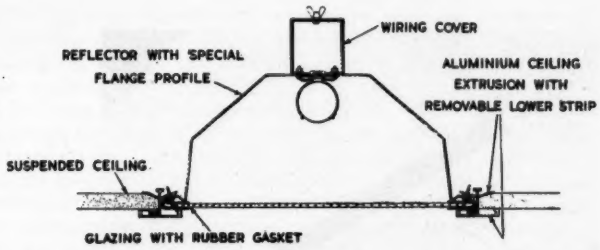
WIRING COVER
REFLECTOR WITH SPECIAL FLANGE PROFILE
ALUMINIUM CEILING EXTRUSION WITH REMOVABLE LOWER STRIP
SUSPENDED CEILING
GLAZING WITH RUBBER GASKET

Fig. 17. Section of extruded aluminium frame ceiling to take trough fittings and sliding glazing.

(5.8) Flush Louvred and Flush Panel Lighting

There is a rapidly growing appreciation of the excellent lighting conditions provided by fittings let into the ceiling, and screened with either louvres or glazing panels. Already popular for commercial and other offices, these lighting systems are being employed increasingly in certain industries including the preparation and packing of pharmaceutical products and fine assembly work.

These fittings necessitate some form of false or suspended ceiling, and many of the earlier installations of this kind have been architect inspired.

There are a number of proprietary suspended ceilings available and in general use, some of which lend themselves readily to this treatment although others require considerable modification.

Fig. 17 shows a section of extruded aluminium framed ceiling adapted to take special vitreous enamelled trough fittings and sliding glazing. In practice too little tolerance is allowed in some of these ceilings, particularly when vitreous enamelled reflectors are used, which tend to distort during the firing process and cannot subsequently be pulled into shape. In fact, vitreous enamel should be avoided where large areas require to be accurately related to each other, and for this type of installation anodised aluminium is by far the best material to use.

There are many other instances where this method of lighting has been specified and detailed by architects; each calls for a variation in the fittings design and necessitates the production and costing of special troughs and suspensions.

Continuous luminous panel lighting offers most difficulties, since the control gear must be housed above the reflectors and bridge pieces formed to connect the longitudinal ceiling members over the top of the fittings. Unless, therefore, continuous panels are essential, it is recommended that the runs be split by blank intervals of a foot or so, allowing the control gear to be placed more accessibly and greatly facilitating both manufacture and erection.

Flush and recessed lighting forms the subject for a whole paper, and as a problem may be resolved in a number of ways. One immediately apparent solution is to design a standard fitting which can be applied without modification to as many of the proprietary ceilings as possible. Fig. 18 shows a section of a fitting designed to go between standard 2 in. joists on 14 in. centres, the shallowest permissible joist being 7 in. This is suitable for many

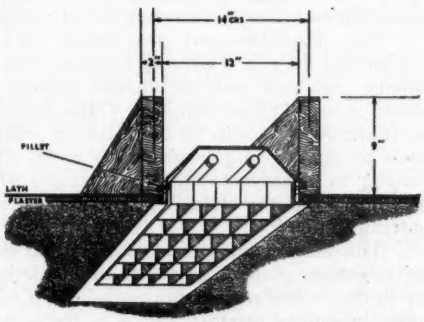

Fig. 18. Section of flush louvred fitting to fit between joists.

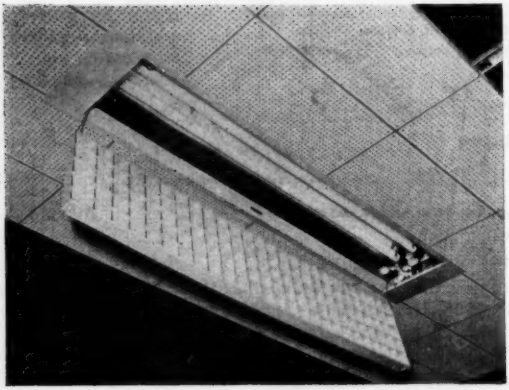

Fig. 19. Flush louvred fitting in ceiling boards.

older buildings having lath and plaster ceilings, and if these be cut away carefully, making good should not be necessary as there is a wide flange round the bottom of the fitting. The control gear is housed on shelves at the end of the fitting, which is dust-tight from above. The fitting is also virtually interchangeable with certain ceiling boards as shown in Fig. 19.

Curiously enough, the "Louverall" ceiling is a relatively simple construction because it presupposes a cavity of suitable depth in which standard batten, seagull or reflector fittings can be housed, and there are a number of proprietary suspended ceilings in which plain louvres can be substituted for ceiling board.

If glass or acrylic plastic glazing is used, a "luminous ceiling" is obtained.

(6) Conclusions

The examples of special design work referred to in this paper are drawn from the author's experience, but reference to the literature shows that many developments are in progress at the present time.

These developments are mainly due to the introduction of the fluorescent lamp which has changed the concept of fittings design from something almost static and circumscribed into a wide and complex field of engineering.

The possibilities are also being more widely appreciated of interior lighting design and there is a growing understanding of each other's problems and aspirations among architects and consultants, lighting engineers and equipment designers. To quote a well-known architect, "The architect, with an increasing realisation that constant developments in this field are offering him a most co-operative henchman, calls on lighting to give him many of his effects—some subtle, some forthright—thus helping to define and enhance the spaces which he has created. To-day lighting has reached a position where it strongly influences—and in some cases determines—interior design."

This may be interpreted to mean that the architect is beginning to think in terms of brightness patterns as a part of his design work. Similarly, the lighting engineer of to-day is becoming more conscious of his position as collaborator in determining these brightness patterns, and is at the same time responsible for converting lighting concepts into practical engineering terms. Finally the work of the lighting equipment designer is, of necessity, becoming increasingly interrelated with the functions not

only of the architect, the lighting engineer, the contractor and the maintenance engineer, but with the manufacturer of lighting auxiliaries and lamps.

It is worth while considering these factors influencing fittings design which compel fresh design work to be undertaken.

Firstly, the lamp. Not long ago the 80-watt fluorescent lamp was the only one of its kind, but this has been followed by a range of similar lamps, and the work involved in providing fittings for these has required a great expansion in design staff. In this country the slim line lamps have not been adopted on any large scale, but at any time additional lamps may be expected which will call for still further fittings.

Every time there is a change in the physical dimensions of chokes, there is an inevitable change in fittings design involving a great amount of work, and even a change in circuit or some small auxiliary part has its repercussions.

Standard fittings have been briefly discussed, but industrial applications alone demand in addition dust-proof, flameproof, acid-resisting, and other varieties of fitting, each involving exacting design work, tooling, packaging, stocking, etc.

An increasing number of projects call for some degree of integration with allied trades; for instance, the metal and plaster technique not only imposes unfamiliar materials on the fittings designer, but depends upon the help of a building trade for the completion of the fitting proper, or in the case of universal lighting trunking, by obviating conduit and affording other facilities, there is a tendency to merge the actual lighting fitting with work normally identified with the electrical contractor.

These new methods of applying light have come to stay, though perhaps not in their present "made-to-measure" forms. On the other hand, from a design point of view, the situation can become chaotic if uncontrolled, making rationalisation essential wherever possible

Already fittings for cornice lighting are being standardised, as also are the flush-louvred and similar fittings. In America the "Module" and other unit constructions have been developed.

The task of fittings designers is difficult, even when meeting day-to-day requirements, but the creation of new features and methods which can be standardised is the real challenge to the industry, demanding co-operation from all concerned if the challenge is to be effectively faced.

The author wishes to thank Mr. V. C. H. Creer, Director of Lamp and Lighting Sales, British Thomson-Houston Company, for permission to publish this paper, and his several colleagues and friends who have made helpful suggestions.

Discussion

MR. A. H. OLSON: Mr. Hubble has given us a great wealth of infomation on fluorescent lighting: we are familiar with all this information to a certain degree, but it is useful to have it condensed as it is in this paper. I do not, however, agree with Mr. Hubble on the title of his paper: "The Design of Interior Lighting Equipment" is a very wide subject covering a large field.

Mr. Hubble has mentioned that the tungsten fitting has not been capable of any improvement since 1937. This may be true for industrial fittings, but I cannot agree so far as commercial fittings are concerned. In the past few years the Scandinavian trend has crept into this country as was seen last year at the Festival of Britain Exhibition.

Coming to another part of the paper on lamp variables, I was sorry to see that the 8-ft. fluorescent lamp had disappeared. I feel there is an application for that lamp. I was on the Continent recently and saw a hair-pin fluorescent lamp with the lamp-holders practically adjacent to each other, and I cannot help feeling that from the

design angle it gave a new outlook as far as fluorescent fittings are concerned. Commercial lighting has demanded a better quality of light, and in the combination of tungsten and fluorescent light sources we have seen some bad examples in the post-war years as illustrated by long tubular fittings incorporating fluorescent lamps with tungsten lamps at the extreme ends of the unit.

Another point I would like to mention is the complex nature of engineering involved with the lighting of the future. There is an increasing tendency towards area lighting, such as "louverall" and suspended ceilings in which lighting is made flexible by means of interchangeable panels incorporating lighting units in the suspended grid, with acoustic materials linked with the panels. Heating problems of close-suspended ceilings are with us, and I feel that the ventilating engineer will become part of our industry of the future.

MR. COOKE-YARBOROUGH: I was particularly interested when Mr. Hubble talked about "rationalisation," and I wondered about standardisation and whether we shall be able to rely on various manufacturers giving us a product which we know we shall be able to fit into a given space. I was planning recently with one manufacturer's goods in view, but had to change and found that the goods from another manufacturer were entirely different. I think there should be standardisation.

I think that continuous trunking is an absolute blessing, particularly for those of us who are concerned with industrial work. It does away with conduit and the lamps can be placed exactly where they are wanted. The particular fittings shown in the paper make provision for other services, which is something I have always wanted. The G.P.O., however, will not, I believe, allow their lines to be placed in the same trunking.

I think there is a tendency these days to swing towards the American "louvred" ceiling with the lamps behind, and there is a real danger that we shall get something rather like indirect ceiling lighting without any sparkle.

I am a little unhappy about the use of the cornice for lighting. I think, perhaps, this is the place where the illuminating engineer is encroaching upon the architect's field. I do not think it is fair to take away the cornice and substitute fluorescent light.

DR. H. H. BALLIN: We all feel that rationalisation is most important, but why was the question of rationalising control gear left out? Many manufacturers are still using individual chokes, capacitors, etc., and I would like to hear Mr. Hubble's views on the advantages or disadvantages of combined ballast.

On the subject of trunking, reference has already been made to the desirability of accommodating different services in the same trunking system. In the system developed by my Company, there is a separate compartment for power or communication cables easily accessible from the top, so that the addition of new cables at a later stage presents no difficulty.

Finally, there was a point raised about louvred ceilings and the question of sparkle. I do feel that a standard metal louvred ceiling, particularly for large areas, becomes very monotonous, but there are alternatives such as having dark areas in between. The recently developed ribbed transparent plastic louvering provides a very attractive sparkle and looks more interesting than the metal type of louvre.

MR. H. F. STEPHENSON: The author has referred to the low ratio of depreciation due to dirt collection in fittings designed for horizontally operated H.P.M.V. lamps. The theoretical advantage over fittings with vertically operated lamps is large, and appears to be borne out in practice in very dirty industrial atmospheres. Some tests made a few years ago indicated that in the less dirty, and more usual, atmospheres the advantage is smaller than theory would suggest. One factor may well be the

greater rate of dirt collection on the upper horizontal surface of the lamp jacket, and I would like to have the author's views on this point.

I regret that the author has expressed the cut-off angles of fittings as measured from the horizontal, and not as specified in B.S. 669 from the downward vertical. This practice of using the horizontal as the datum has increased in recent years and leads to confusion, especially with louvred fittings having a cut-off angle in the region of 50-60 deg., where it is not clear by inspection which convention is being used.

Lastly, in connection with the continuous fluorescent fittings mounted below the crane rails as described in Section (5.2), it has usually been found necessary to shield side mounted light sources to prevent glare to the crane driver, and I should like to know whether the brightness of the fluorescent fittings is low enough to avoid fitting louvres.

MR. S. ANDERSON: The first point I want to make relates to what Mr. Hubble has referred to as "rationalisation" or "standardisation." I serve on one or two British Standards Committees and I am beginning to formulate strong views about standardisation. It seems to me that there are two alternative ways to standardise a product, and there are serious difficulties in both. If one formulates a standard for something which has never previously been made, one is extraordinarily lucky if the standard proves to be a good one and is accepted both by manufacturers and users. If, on the other hand, one waits until there have been several years of experience—the trial and error method—all too frequently the manufacturers have spent a large amount of money in buying tools and equipment to make their individual designs, and when the standard specification is produced there are inevitably strong objections from manufacturers whose well established practice does not enable them to comply with the standard without incurring additional expense.

It is quite obvious that fluorescent fittings have passed the first of the two periods I have indicated, and I think that to try and standardise even an industrial fluorescent fitting at the present time would be to cramp the natural course of evolution now in progress. It does not seem to me that we are yet approaching the end of the development period, but I would be interested to have Mr. Hubble's reactions on this matter. We missed the early opportunity, and I think if we standardise fluorescent fitting designs at present in any but the broadest manner we shall stultify progress.

I was sorry to hear Mr. Hubble expressing the view that tungsten filament lamp fitting designs have remained more-or-less static since 1937. I do not know whether he was referring only to industrial tungsten filament fittings. There are certain basic designs which have remained the same since 1937, but I think there have also been quite a number of advances; for instance, if I remember correctly, the "through-draught" type of fitting with a ventilated top has been produced since then. Certainly the use of the pressure die-cast cases and canopies has come since then, and has led to great improvement in many designs of utility fitting.

Perhaps through lack of space and time, Mr. Hubble has not included in his paper one thing which I am sure it pays all fluorescent fitting designers to bear firmly in mind. They are concerned not only with a housing for the lamp but also with housing for the control gear. We have seen illustrations showing "nests" of fluorescent lamps in built-in fittings, which must involve corresponding "nests" of control gear behind. These will generate quite a lot of heat, and I think it would have been useful if Mr. Hubble had indicated the methods used to dissipate this heat and avoid excessive temperature build-up, the ill effects of which we all know too well.

MR. W. A. R. STOYLE: Mr. Hubble refers to "... the recent introduction of the MA/U discharge lamp, which can be operated in any position, makes the use of the magnetic arc control optional." I would like to point out that mercury vapour lamps

capable of being operated in this manner have been made and extensively used since about 1936. These lamps were at one time referred to as type MA/U, but the nomenclature has now been altered to type MA/H. Both type MA/H and MA/U lamps operated horizontally without magnetic arc control have an efficiency about 10 per cent. less than normal lamps designed for vertical burning.

MR. IAN S. PLUMTREE (communicated): I think Mr. Hubble seems confused about the 20 deg. angle cut-off of the Standard Dispersive Reflector. He talked of it as being from the vertical plane which, of course, is not so.

The regulation states: "Where any light source in a factory is less than 16 ft. height above floor level, no part of the source or fitting having a brightness greater than 10 candles per square inch shall be visible to any person whilst normally employed within 100 ft. of the source, unless the angle of elevation from the eye to the source exceeds 20 degrees." Thus the vertical cut-off would be 70 deg. I believe B.S.S. No. 232 has something to say on the above lines.

Fig. 18 shows a flush-louvred fluorescent fitting between joists. I should like to hear from the author how accessibility is gained to remove the control gear for maintenance purposes.

MR. HUBBLE (in reply to the discussion): I am sorry Mr. Olsen does not agree with the title of my paper, but at least it has the merit of indicating what it is about.

With regard to the improvements in tungsten fittings since 1937, I admit there have been small changes, and replying to Mr. Anderson at the same time, I agree that the "through-draught" type of fitting is one which I might have included, but, generally speaking, it is true to say that we were well equipped with tungsten fittings in 1937.

Mr. Olsen refers to the Scandinavian trend, but I would suggest that its impact is slight, and in any case I cannot agree with this worship of what I described as "comic" sections. With regard to the 8-ft. lamp it is not true to say that this has disappeared, but the demand has fallen considerably below expectations. Regarding the problems involved in suspended ceilings, I agree with Mr. Olsen that the scope of a lighting engineer will have to be considerably widened and cover many other allied trades.

Replying to Mr. Cooke-Yarborough, I agree that standardisation of suspensions and conduit entries into fluorescent fittings is most desirable, but it has been found that in order to accommodate the various types of control gear—particularly where the same section of backbone may be required to house both one and two sets of gear—it is extremely difficult to standardise even one manufacturer's fittings. The answer may be found in the use of the T-slot technique, to which I have referred in my paper, and there is no doubt that such standardisation is highly desirable. I agree with Mr. Cooke-Yarborough that the G.P.O. will not normally permit their cables to run in common trunking.

With regard to the example of cornice lighting, I quite expected an architect to object, but I did point out that it was a compromise which detracted least from the inherent beauty of the architecture.

Dr. Ballin asks whether I am in favour of combined ballasts, and the answer is, of course, that I am very much in favour of combined ballasts having two large terminals at one end to accommodate the mains wiring—preferably looped in—and four terminals at the other end for the two pairs of lamp leads. It does not follow, however, that such combined ballasts are a simple matter either to design or manufacture, and he must be fully aware of the difficulty of heat control, watts loss and other factors associated with such combined units.

While I am in agreement with Dr. Ballin regarding the monotony of "louverall"

ceilings, I cannot see how any ribbed plastic can add sparkle, since the brightness of the plastic cannot exceed that of the lamp, and no sparkle can really be produced without the addition of high brightness sources.

Mr. Stephenson's suggestion that the advantages of horizontally operated HPMV lamps are apparent only in very dirty industrial atmospheres is not borne out in practice, and his suggestion that in less dirty and more usual atmospheres the advantages are less, is not borne out by his further suggestion that the horizontal lamp has a greater rate of dirt collection than the vertical lamp. If that were so then his experience should be the reverse of what he implies.

I appreciate the fact that I used the expression "20 deg. cut-off" somewhat loosely, but I think I may be excused since it refers to a specific angle referred to in the Factories Act and has, for that reason, become common parlance.

With regard to glare from crane-rail lighting. the brightness of the crane-rail fitting is of such a low order that no sensation of glare is experienced; in any event, the crane driver is usually in a cabin suspended below the light sources and with his back to those nearest him.

Mr. Anderson's reference to standardisation rather indicates that I have not made myself clear. I did not think that I had used the word "standardisation" at all. What I was trying to point out was that in many component parts it might be possible to make one thing do two jobs, and as the whole concept of lighting appears to be changing, in meeting these conditions one should be always on the alert to see if it is possible to rationalise certain components.

The main object in spending so much time on the blended light unit was to show how a series of different fittings had been developed against specific field conditions and could, in point of fact, be reduced to a series of common components.

With regard to the fittings having nests of fluorescent lamps built in, the question of heat, of course, has had to be met, but I would assure Mr. Anderson that it can be adequately met in a properly designed fitting.

In reply to Mr. Stoyle, I would state that in my original text I referred to the reintroduction of the MA/U lamp because, like him, I knew that such a lamp had been introduced in the past, but I was told, on the best authority, that although the MA/H lamp existed, the MA/U has only just been introduced.

With regard to Mr. Plumtree's written contribution, I can assure Mr. Plumtree that at least I was not confused about the angle of cut-off, even if my audience was, and I am grateful for Mr. Plumtree's quotation from the Factory Regulations which appears to make my excuses for me.

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Printed by
ARGUS PRESS, LTD.,
Temple-avenue and
Tudor - street,
London, E.C.4,
England.

XUM